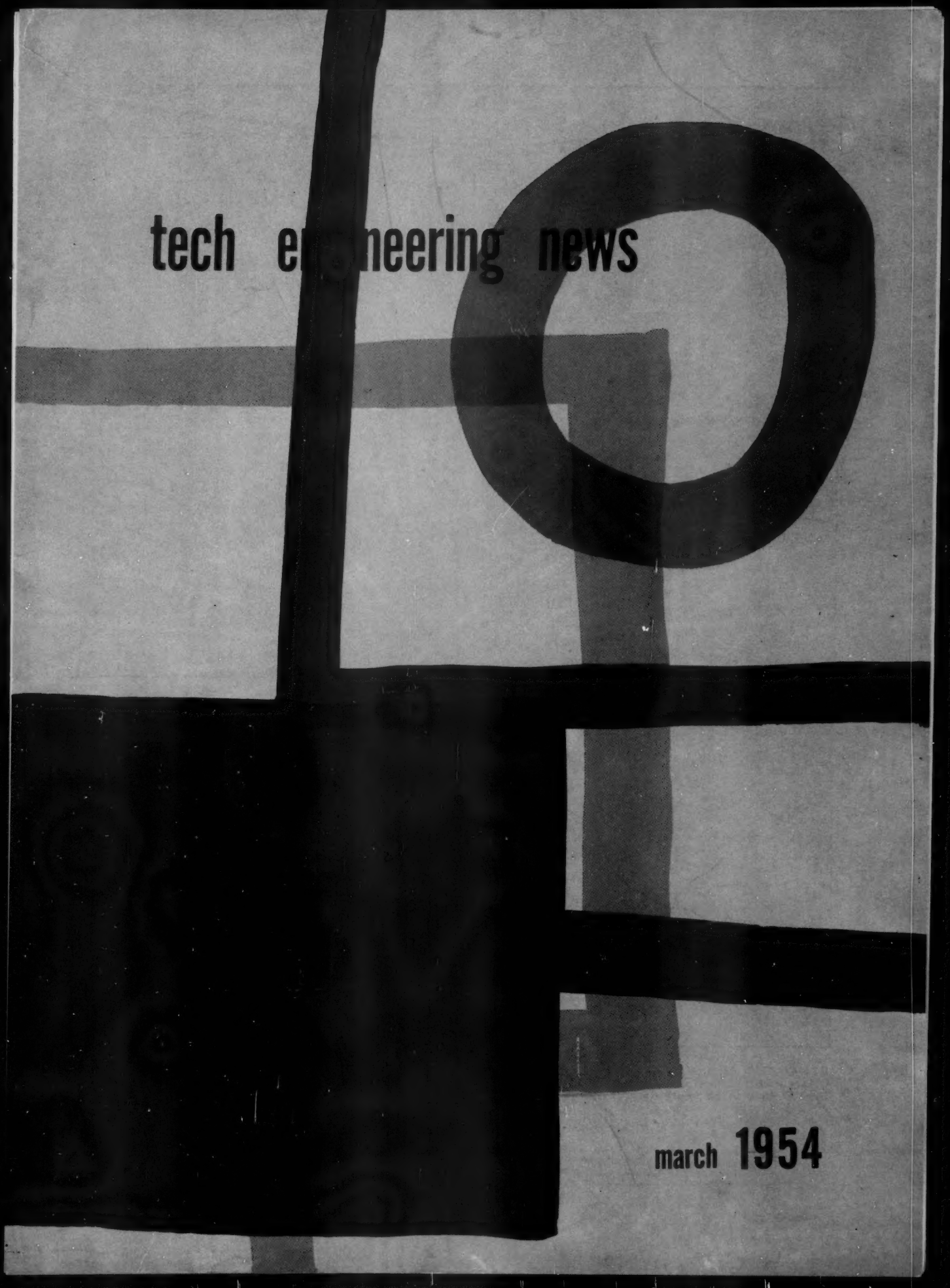
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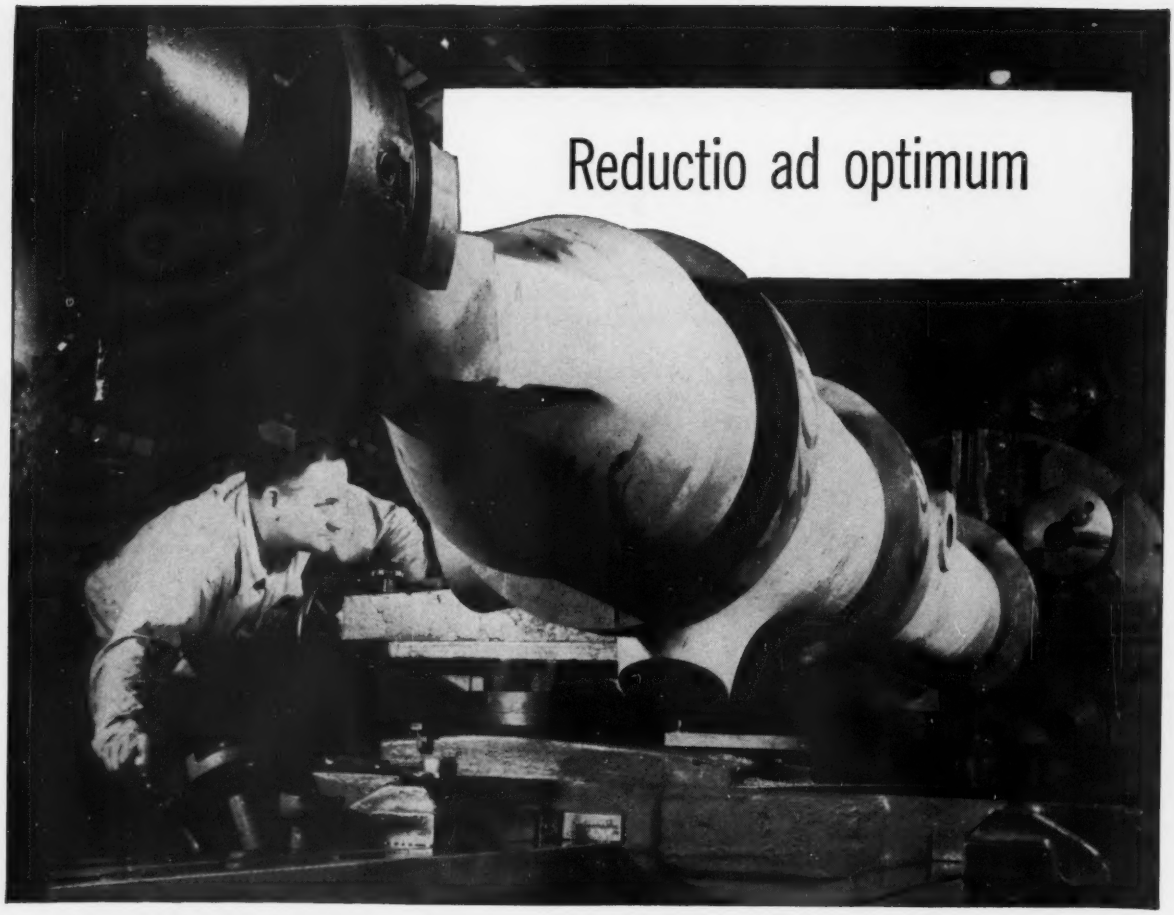
march 1954



Reductio ad optimum

U·S·S CARILLOY electric-furnace aircraft quality steel meets every requirement for these vital parts. The precision machining and expert heat treatment it gets at Cleveland Pneumatic Tool Company complete the job.

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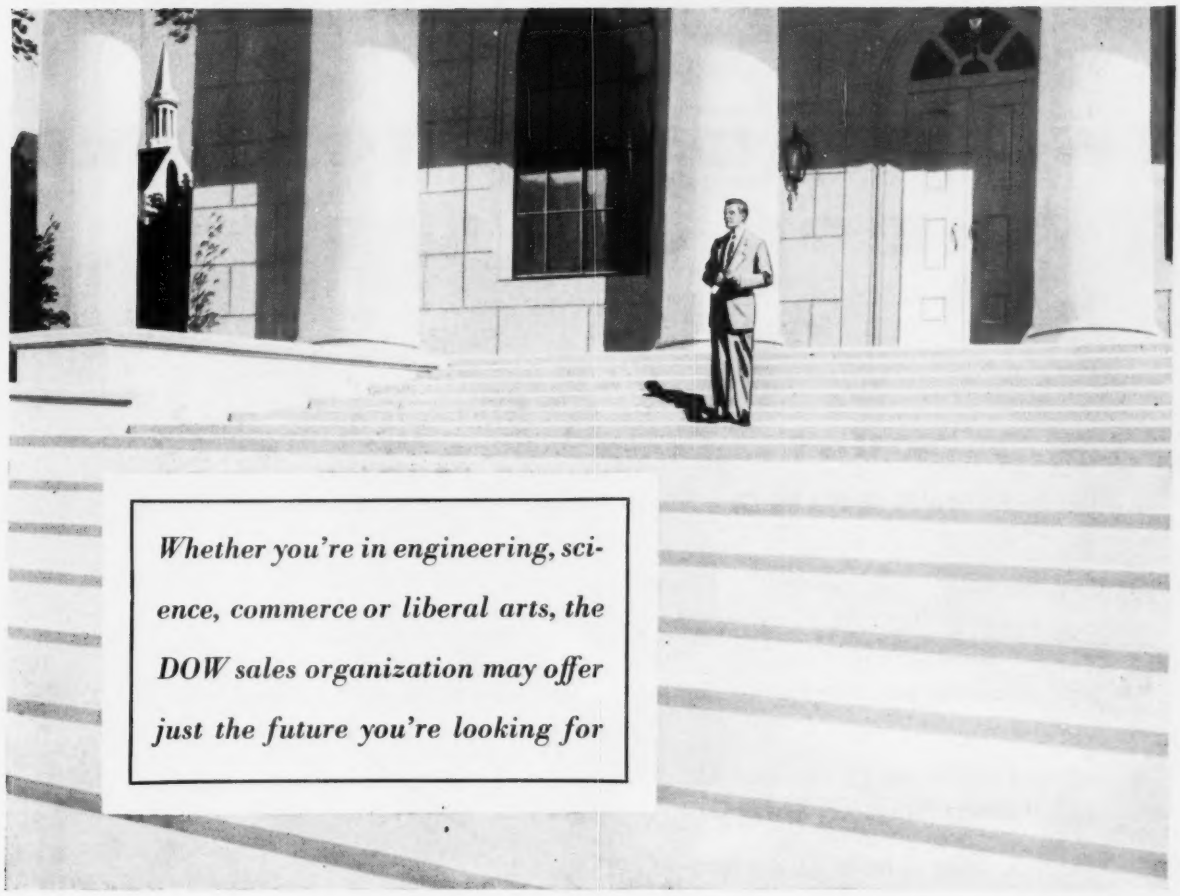
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TWO MORE WAYS TO CLIMB THE GM JOB LADDER

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PRODUCTION ENGINEERING

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The kind who likes to be in on the *birth* of an idea? Or the kind who likes to meet the challenge of new designs, new inventions, new ideas — by figuring out how to *build* them in quantity at a price to make them available to the greatest number of people?

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A MESSAGE TO COLLEGE ENGINEERING STUDENTS

from A. C. Montieth, Vice-President in Charge of Engineering and Research, Westinghouse Electric Corporation, *Queen's University, Kingston, Ontario, 1923*

The second most important decision in your life

Now, as you near graduation, you are about to make a decision—second in importance only to choosing your life's partner.

I'm talking, of course, about that all-important first job. Which company will it be? I wouldn't presume to answer that question for you. But I would like to emphasize the importance of this decision.

You have a lot at stake. The direction your career takes will most certainly be influenced by the company with which you cast your lot. May I offer a few personal suggestions.

Choose a company not for its bigness or smallness, but for how it will treat you as an individual. Choose it not only for its engineering activities alone, but also for how it is set up to help its engineers develop themselves professionally. Choose your company with an eye on the opportunities ahead—and an eye on the future of the company itself. Above all, select a company that has a definite program to help you determine the work for which you are best fitted.

Only you can make this vital decision. Whatever it may be—good luck!

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tech engineering news

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FRONTISPIECE

Dorrance Laboratory

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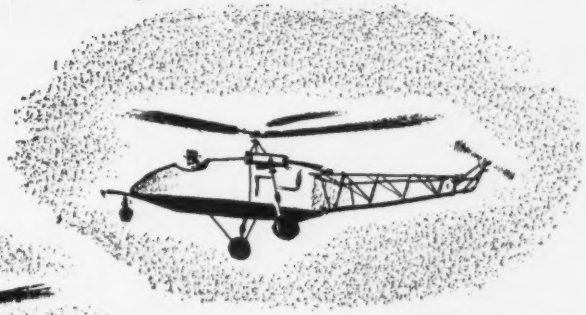

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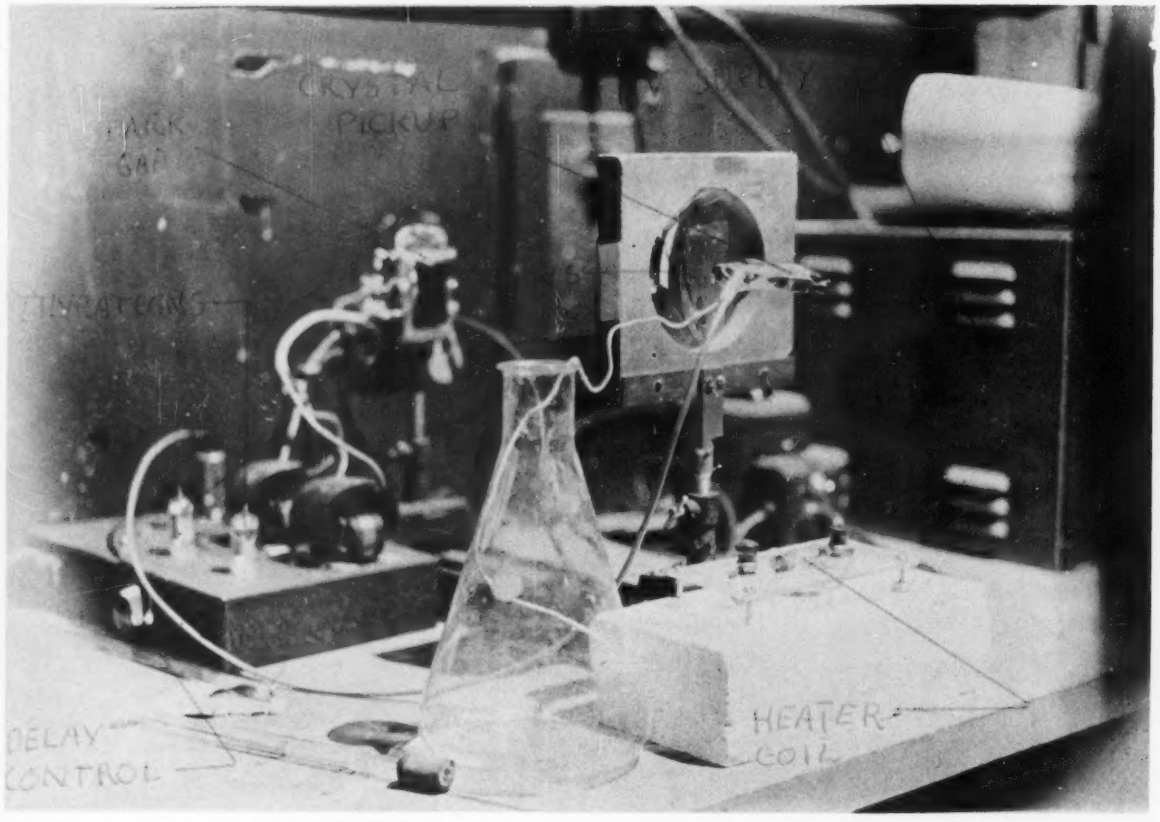
high-speed "spark" photography

by George Schwenk, '54, Richard Morley, '54 and Henry Hirsch, '54



Some of the equipment used in photographing the shock wave photographs.

The course in Experimental Physics is intended to be an introduction to experimental research techniques. The assigned laboratory exercises are concerned with fundamental principles in optics, nuclear, atomic and molecular physics, and are designed to bridge the gap between the elementary laboratory and modern physical research. The following is a resumé of one such exercise, showing the many facets of physics which enter into more advanced work in the undergraduate field.

The Editor

This article is concerned with a group experiment performed last fall in the 8.11 Experimental Physics laboratory. The result, as reported here, provides an example of high-speed photography of shock waves with very simple equipment. It should be made clear at the outset that the word "spark" in our title is a misnomer. Electric sparks were used as the source of illumination for the photographs, but were not themselves investigated in any way.

Our experimental objectives included a photograph of a rapidly moving object and a double exposure photograph of a shock wave, which would show it at two stages of its existence on a single piece of film.

Since shock waves were the subject of most of our photographs, we will consider some of their properties before continuing. Shock waves were produced for our experiment by a small explosion. When an explosive is detonated, large volumes of heated gas are liberated. The gases, if not obstructed by solid objects, expand spherically at a velocity not limited by the speed of sound. Gradually the molecules of the hot gas transfer their momentum and energy to the molecules of the air which surrounds them. This is manifested by a sudden change of density of the air in a thin

spherical shell expanding from the source of the explosion at the speed of sound. Such a "dense place" in the air is what is commonly known as a shock wave.

The question now arises as to how something as nebulous as a change in a transparent gas such as air can give an image that will record on film. The answer lies in the fact that the index of refraction of air varies linearly with its density. The slowing of the light rays in the dense portions of the air causes a distortion of the wave front similar to that which occurs in a prism. The rays are bent in such a way that an increase in air density causes a dark line where the light has been bent aside, followed by a light region into which the light rays have been redirected.

Our optical system was roughly similar to that of an enlarger. Our light source, the spark gap, would correspond to the enlarger lamp. From the source, the rays pass through a condenser lens. Next the object is encountered, the negative in the enlarger or the shock wave in this case. Finally the light is gathered in the lens of the camera or enlarger and focused on the film or enlarging paper, as the case may be. Other more complicated systems, such as the Schlieren or Interferometer methods could be used for greater sensitivity if the light were sufficient.

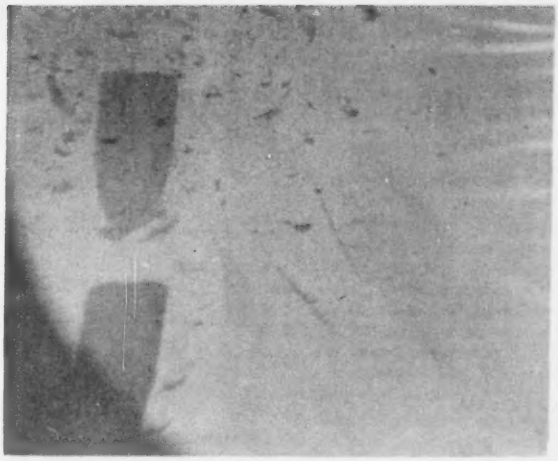
In our operations no shutter was used for timing. The duration of the spark (around 1 microsecond) determined the length of exposure.

The electronic circuit which was used to provide the necessary timed light flashes was suggested by Professor Edgerton of the Electrical Engineering Department and was used extensively in studying the characteristics of dynamite caps and other high-speed phenomena. It provides two light flashes of less than a microsecond duration with a continuously adjustable time delay up to about forty microseconds.

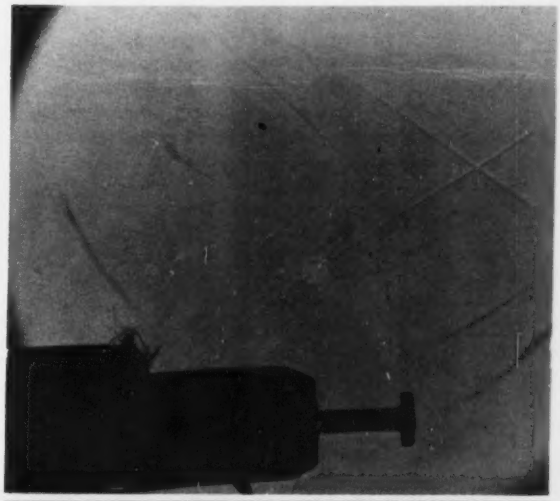
The sound of the explosion is picked up by a conveniently placed phonograph crystal, and the resulting voltage is amplified and used to trigger the thyratron circuit. The thyratrons produce two sharp voltage pulses with the desired time delay. Each of these pulses is then used to break down one of two special three electrode spark gaps. These gaps act as high speed electronic switches to shunt in rapid succession two high voltage sources across one light gap. As a result, the required two high intensity light flashes are produced in the light gap. The circuit diagrams of the thyratrons and the spark gaps are shown for those readers who are interested in their operation.

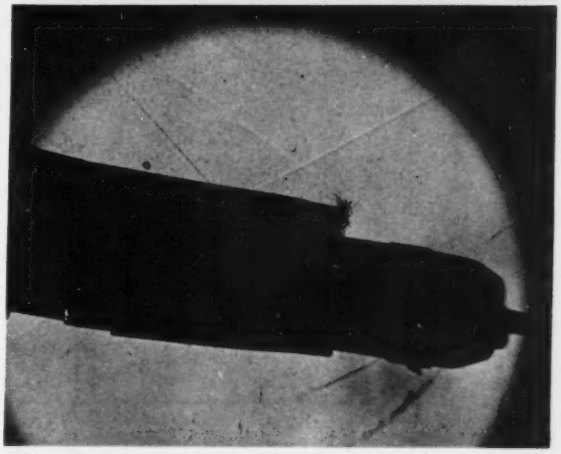
One of the important problems of the experiment was to find a suitable source of shock waves. The ideal source would provide a sharp noise or explosion with a minimum of light and debris. If an explosion is to be used it would also be desirable if the explosive were easy to make or obtain, safe to handle and effective without compression. As a result of extensive research in the field of explosives conducted in East Campus over the past few years, we decided that silver carbide was the ideal source. To detonate the carbide we used a coil of thin resistance wire and slowly increased the voltage across the coil by means of a variac.

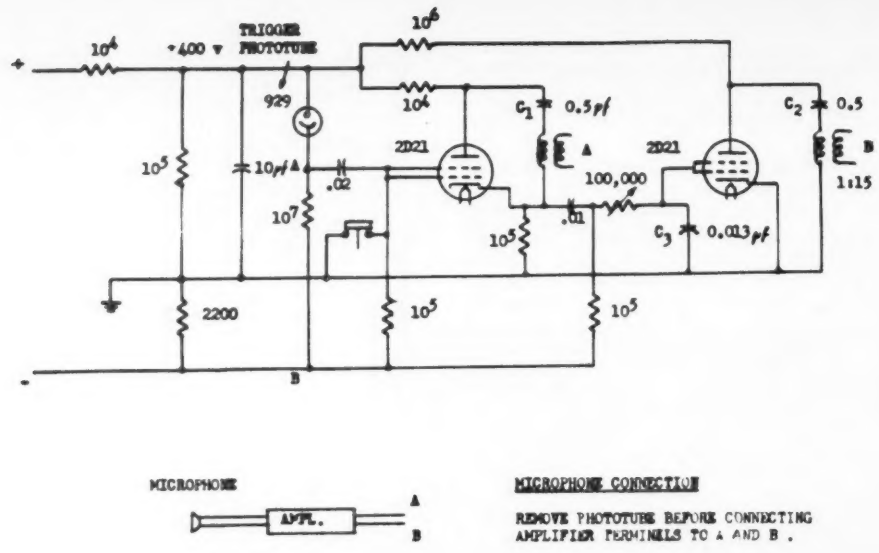
The result of these silver carbide explosions can be seen in the accompanying photograph, one of several dozen that we obtained, which shows the shock wave from one of these explosions. The reader will note that four shock fronts are in evidence. Since this is a double exposure photograph,



Double exposure of .22 calibre rifle bullet demonstrates shock wave. Bullet courtesy John Mark '55. Double exposure records shock waves from an explosion of silver carbide. The shock waves are very faint in comparison to the many scratches and other blemishes on the film.







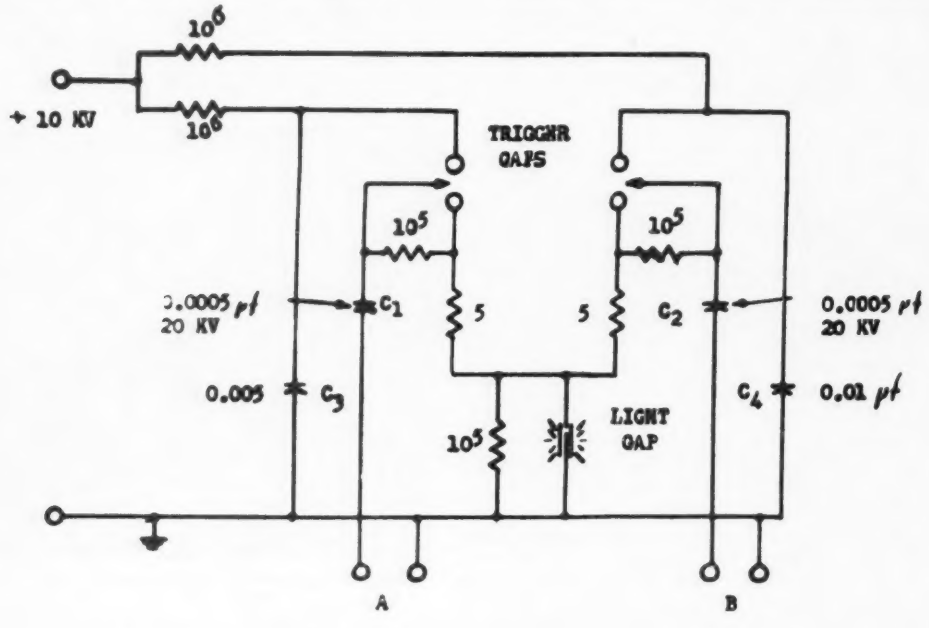
This thyratron circuit is used to trigger the spark.

two of these images are simply the same wave at a later time. The other duplication is due to reflection from the two sides of a sleeve which we used to concentrate the force of the explosion.

As another portion of the experiment we attempted to photograph a .22 calibre bullet, again using the double exposure method. As can be seen on the accompanying picture, this was successful. In addition, one can observe a very faint shock wave trailing from the tip of the second (forward) image of the bullet. Since we can assume that the velocity of the shock wave perpendicular to the path of the bullet is equal to the speed of sound, we can take any point on this path and state that the ratio of the distance from this point to the tip of the bullet, to the distance from the point to the shock wave (in a perpendicular direction) is equal to the ratio between the speed of the bullet and the speed of sound. Using this calculation we find that the velocity of the bullet equals 1195 feet per second. This compares favorably with the manufacturer's muzzle velocity rating of 1250 feet per second.

Now, knowing the speed of the bullet and the distance between the two images of the same (corrected to account for photographic enlargement), we can calculate the time interval between the two flashes. The result, agreeing well with the expected value, is 40 microseconds.

This sort of experiment, while not likely to yield any world-shaking discoveries, is extremely interesting in the varied problems that it raises and in the combining of optics, photography, electronics, and pyrotechnics into one problem.



The spark gap circuit shows the two trigger gaps and the light gap.

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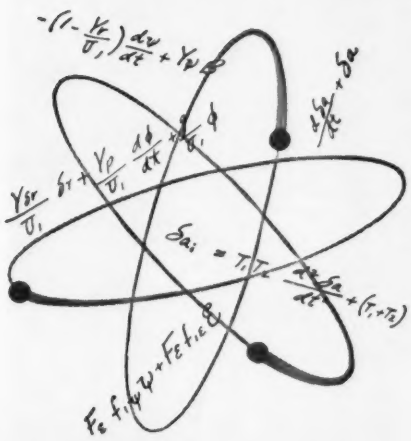

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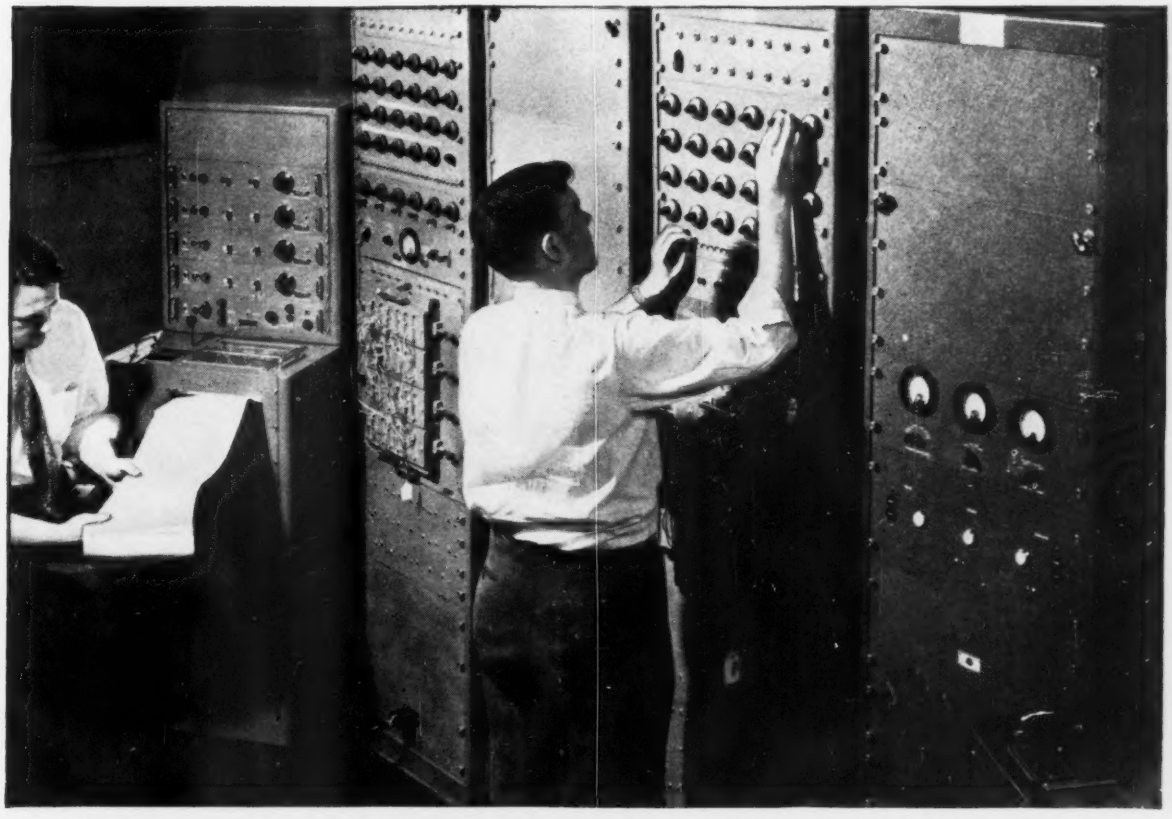

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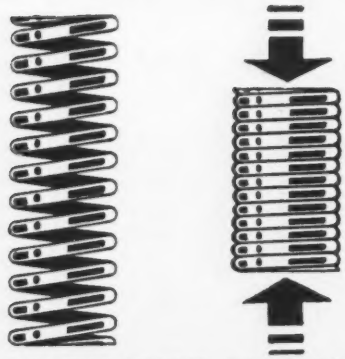

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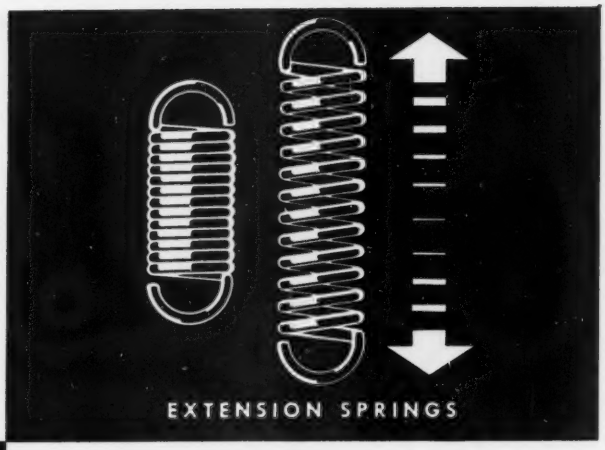

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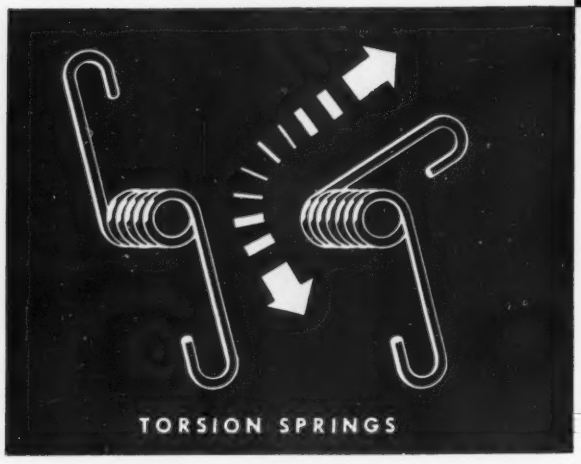

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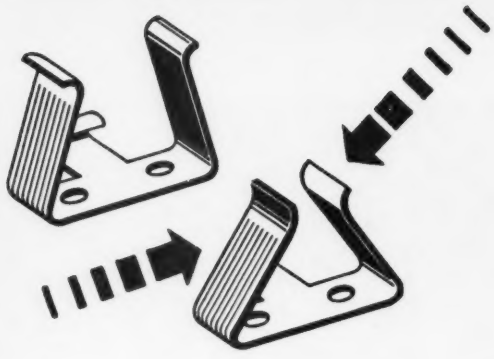

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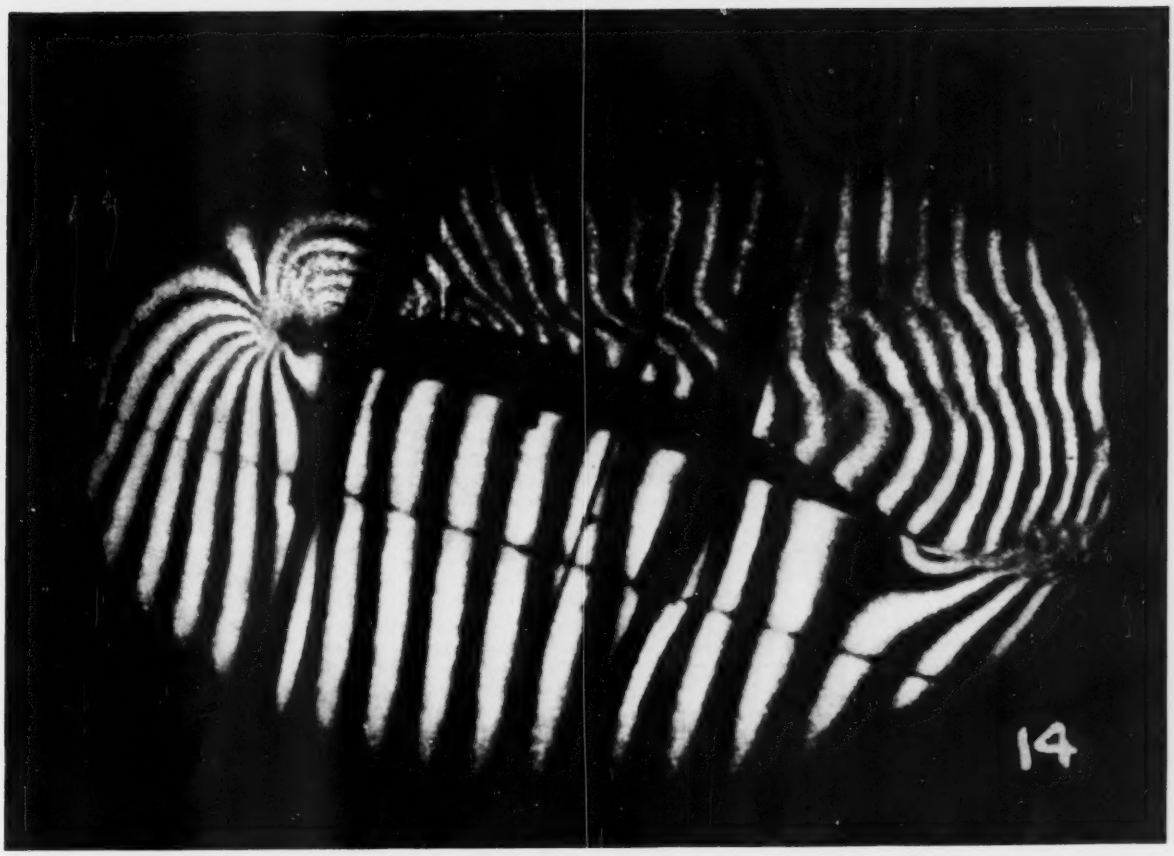

fingerprint of a flutter . . .

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from the editor's notebook

Faculty - Student Relations

After three and a half years of armed truce, the M.I.T. faculty and student body are thrown abruptly together in a grim and confused game, the purpose of which is to round up professional references. Like a horde of locusts, students descend upon long forgotten professors in search of these references. When we had ourselves finished this hectic scramble, and had realized how few faculty members in our department (physics) we really knew, we started checking with fellow students to find out what luck they were having. The results were grim; most students were having trouble finding as many as two references in their own department. The courses had been so thoroughly shuffled, and the faculties in most departments were so large that few students had ever had the same recitation instructor in two successive courses. Registration officers (except in the case of one foresighted professor who took a leave of absence this year) were invariably used, being inundated with reference forms. A professor who had the misfortune to be nominally in charge of a senior laboratory course, which he occasionally visited, seeing each student for perhaps one hour in the entire semester, was showered with reference forms from thirty or forty students. Recent instructors, freshman professors, and the humanities faculty made up the rest of the references. Of the whole group mentioned above it is probable that the humanities faculty members know the students better than any of the others. The sad fact is that few students in the large departments know a single faculty member in their department well.

What then is the result of this situation? First, references are largely ignored in evaluation of students, unless they are enthusiastic and show unusual knowledge of the student. Second, and more important, the average Tech student has gone through four years of education, in contact with some of the top men in his field, without getting to know one of them personally. The student might just as well attend lectures by television, and send in homework assignments and quizzes by teletype.

However, in most of the smaller departments, such as geology, meteorology and biology, the situation is much improved. The same instructors are met in successive courses; the classes are small; and most students know personally every professor in the department. Formal course assignments can be minimized for the faculty member knows how each student is doing without endless quizzes, and the students generally avoid the cram and quiz routine of too many MIT courses. One result which might be attributed to this advantage of the small courses is the relatively large number of activities engaged in by their members: on both TEN, the Tech and the Outing Club, for instance, geologists comprise a rather large proportion of active members although geologists number less than 2% of the student body.

Also, the humanities department enjoys similar advantages with regard to student faculty relationships. Why? Classes are smaller and more informal, and what is more important, professors are *available*. How many of you have had the experience of spending an entire afternoon tracking down a professor, and then giving up in disgust after getting the run-around?

What can be done to further student-faculty relations? Slice student-to-instructor ratios in junior and senior professional courses. Thirty freshmen to a recitation instructor might be all right (maybe freshmen don't like to ask questions anyway), but thirty seniors are too many. Make instructors available. A couple of two or three hour stretches when the faculty member would definitely be in his office would be a great incentive to look him up if necessary. Finally, the attitude of the faculty itself is the most important and necessary ingredient; M.I.T. would be an educational institution which sponsors research only to further the cause of education, not an industrial laboratory which runs a tutoring business as a sideline.

R. D.

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recent ship failure studies

by Richard J. Hayes, '54

ABSTRACT

The following is a survey of the recent investigations made by various agencies as a result of the many ship failures which occurred during the past decade. This report describes the major factors, as concluded by the investigators, which contributed to the many failures. The object of all the investigations was to determine the cause and to find methods which would eliminate the failures.

The results of the investigations indicate that there is no guaranteed method of eliminating the failure phenomenon. However, suggestions which would greatly assist in the prevention of the fractures are mentioned in the discussion section of this report.

INTRODUCTION

The breaking up of welded merchant ships during World War II brought the ship failure problem into sharp focus and a great amount of data has been accumulated as a result of the ensuing research. The purpose of this article is to survey the results of the many studies which were undertaken by various organizations in an attempt to shed light upon the ship failure problem.

The necessity for detailed research in the structural design of ships becomes evident upon examining the statistics of brittle failures of welded ships over 350 feet long. Only a few similar failures have occurred in smaller vessels. From November 1942 to December 1952, more than 200 welded ships suffered one or more fractures of such severity that the vessels were lost or in dangerous condition. At least ten tankers and three Liberty ships have broken completely in two as a result of the propagation of fractures that originated at some point in the hull or its appendages. In the same period 1200 welded ships suffered cracks generally less than ten feet in length. These cracks did not endanger the ships, but were potentially dangerous. Also, about twenty-five other vessels have suffered complete fractures of the strength deck or the bottom during the same period.

This brittle type failure of steel did not originate in the era of welded construction and its history can be traced back to approximately 1879. Riveted structures also suffered brittle failure, with fractures originating at cracks radiating from rivet holes, or other defects. Since 1900, over a dozen riveted merchant vessels have broken in two during heavy weather or are listed as missing. It is significant to note that most of these vessels were of the tanker type, the same category which gives the most trouble in welded structures.

Although fractures have occurred in riveted ships, these failures usually ended at discontinuities introduced by the riveted joints, and did not propagate into adjoining plates. A welded structure is continuous, however, and a crack may propagate across the welds from one plate to the next and result in complete failure. Due to the increased use of welding in the fabrication of ships, the problem of fracture origin and propagation has received a great amount of attention in recent years.

In April 1943, the Secretary of the Navy established a Board to Investigate the Design and Methods of Construction of Welded Steel Merchant Vessels. The Metallurgy Division of the National Bureau of Standards had already assisted in the investigations of some of the earlier failures, and was requested to continue the investigation of the plates removed from the fractured ships. Since this was one of the most complete investigations into the ship problem, it will be referred to frequently throughout this paper. Properly identified samples of the fractured plates were obtained by the Bureau of Standards through the cooperation of the U. S. Coast Guard and other interested agencies. They found that the vessels in which such failure occurred were of several different types and had been built at a number of different yards. Most of the casualties occurred at low temperatures. There appears to be no significant difference of failure temperature for ships of different types.

OBSERVATIONS MADE DURING SHIP FAILURE EXAMINATIONS

1. General Observations

a. ORIGIN OF CRACKS

It has been found that the starting points of more than half of the cracks in the vessels examined by the Bureau of Standards were in the immediate vicinity of structural features such as hatch corners, ladder cutouts, or at the abrupt termination of stiffeners such as a bilge keel. The origin of fracture at these points may be attributed primarily to the stress concentrations resulting from a geometrical or structural notch, although in nearly every case the metallurgical effects of welding, flame cutting, or mechanical working were also present, and these effects are not separable.

DESCRIPTION OF FRACTURE PHENOMENON

Before surveying the analyses of the investigators, it might be well to summarize the concept of brittle fracture which is also significant in other types of structures as well as ships. Three conditions can combine to bring about such a failure:

1. Low temperature.
2. Presence of a notch or crack—any defect such as a welding crack, void, or a crack left by a punching operation can initiate

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brittle failure which is sometimes called "notch brittleness."

3. High strain rate, or impact loading—this factor, however, is not necessary for the occurrence of brittle failure.

The occurrence of brittle failure may be recognized by several earmarks. Among these are the rapid speed at which fracture occurs, almost complete lack of ductility, negligible energy absorption, and a brittle or faceted appearance of the fractured surface. Moreover, the fractured surface often has a characteristic "chevron" or "herring-bone" appearance with the apex of the herringbone pointing toward the origin of the fracture.

The baffling characteristic of this phenomenon to early investigators is that when steel plate, taken from a structure which failed in a completely brittle manner, is tested in an ordinary tensile test, it exhibits a high degree of ductility and strength. This characteristic has now been recognized, however, and is accepted as a normal occurrence. A graphical explanation of the transition temperature between brittle and ductile failure is given by the typical curves in Fig. 1 and Fig. 2.

Approximately one-third of the reported fractures originated in defective welds, some associated with structural notches, and others in which the only notch was that resulting from welding defects. A few fractures started at the intersection of two weld beads. The origin of these particular fractures probably resulted from the combination of a minor mechanical notch and the metallurgical effects of the successive heating and cooling cycles. Several of the fractures originated at arc strikes on the plate outside the weld zone. Experiments on carbon steel plate in the Metallurgical Division of the National Bureau of Standards demonstrate that an arc strike is an effective notch, and that failures originating at such defects, as observed in ship failures, may be reproduced in the laboratory.

b. PROPAGATION OF CRACKS

An interesting observation revealed by the studies is that the paint or scale on the plate surface generally was not cracked, even very near the surface. This indicates that the fractures had propagated with very little plastic deformation of the steel, and that the stress at points a small distance from the fracture must have been lower than the yield point. It is evident therefore, that very little energy was absorbed in the propagation of these fractures. In the immediate vicinity of the fracture, however, the sharp notch at the head of the advancing crack caused a stress concentration which exceeded the fracture strength of the materials.

c. SHEAR EFFECT AND OTHER OBSERVATIONS

Some of the plates observed by government inspectors were not fractured completely through in a few areas, giving the appearance of an intermittent fracture, and occasionally, cracks several inches long were found on one side of a plate with no visible indication of a crack on the other side. When these fractures were broken apart for examination, it was found that only a thin skin of shell at the plate surface had not been fractured, corresponding to the zones of shear fracture observed near the surface in many of the plates which had been fractured. The "shear lips" or the occasional absence of fracture near the plate surfaces has been attributed to a combination of two factors: greater notch toughness near the plate surface, especially in rimmed steels, and decreased constraint or biaxial stress near the plate surface.

Semicircular or oval markings, similar to the shape of the end of a fracture, were also observed in several plates. Often these marks were accompanied by a difference in the degree of corrosion of the fracture edges, a change in the direction of the fracture, or a slight indication of shear type fracture, indicating that the crack had stopped temporarily at that point and had progressed further at a later time or under different stress conditions.

Before concluding this section on general observations made in the study of ship failures, the effect of a riveted strip or "crack arrestor" on a welded plate should be noted. The realization that a crack in a notch sensitive steel will propagate at a low energy level and that a fracture in a riveted ship will usually stop at the riveted joint led to the installation of riveted straps covering a longitudinal slot in the deck and other locations as a preventative measure to limit the propagation of fractures. The effectiveness of these crack arrestors shows quite conclusively that the propagation of fractures was not a direct result of the loss of the strength and support of the structural members initially fractured, but was primarily due to notch sensitivity.

Another interesting observation made in the

TABLE I

Element	Effect on Transition Temperature
Al	Lowers, then no change. Probably acts by decreasing the grain size, deoxidizing, or tying up the N.
B	Increases, rapidly and regularly.
C	Increases 5°F per 0.1% below 0.30%. Increases 6°F per 0.1% above 0.30%.
Cr	Little effect.
Cu	Raises slightly and decreases maximum energy.
Mn	Decreases, up to 1.5% at approximate rate of 1°F per 0.01%. Amounts smaller than 0.30% were not studied.
Mo	Increases, almost as rapidly as C, and decreases maximum energy.
Ni	Slightly beneficial up to 1.80%.
P	Increases, at rate of 13°F per 0.01%.
S	Induces laminations, and in such cases increases the energy to failure.
Si	Increases, at rate of 1.25°F per 0.01%. (This was later found to be valid for greater than 0.25% Si only. Below this figure Si decreases the transition temperature. See reference 11.) (this report).
Ti, V	First increases, then lowers. This may be because of the effect on carbides.

NOTE: The above table is reproduced from page 68-69 of report by M. E. Shank to the COMMITTEE ONE SHIP STRUCTURAL DESIGN.

ship failure studies is that there was no instance where a crack propagated for any distance in the heat affected zone adjacent to a weld, or continued to propagate in a sound weld after changing direction from the plate into a weld. This indicates that sound weld metal and the metal in the heat affected zones adjacent to a weld are not abnormally sensitive to fracture in a direction parallel to the weld.

2. Results of Laboratory Investigations

a. RESIDUAL STRESS EFFECTS

Many investigations have been performed to evaluate residual welding stresses in the butt welding of ship plate and locked-stress* in ship assembly. The results of these investigations indicate that the basic welding stress patterns were practically the same regardless of the type of ship or where it was built.

As the deposited metal from a weld bead solidifies and shrinks, a state of tension results. Residual longitudinal stresses approaching the yield point in tension have been measured along the length of the centerline of butt welds in ship plate. Values of transverse stress across the weld, however, are low, about 200 to 10,000 psi in tension. These results are found in tests performed on both actual ships and smaller plate samples. Stress values measured in automatic Unionmelt seams were found to be more uniform than those

* In ship reports it has been customary to define residual stresses as those resulting from the welding of unrestrained members. Locked-in stresses have been defined as including residual stresses, and stresses resulting from other assembly and fabrication procedures.

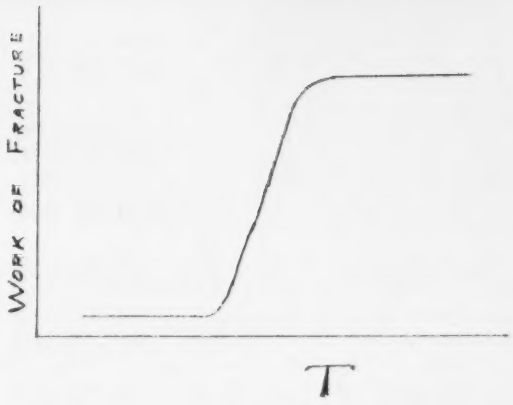

Figure 1. The transition temperature: the "notch impact value" (work of fracture) as a function of the temperature.

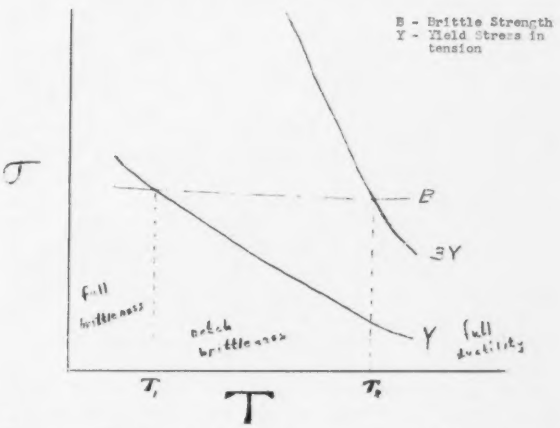

Figure 2. Explanation of the transition temperature. Regions of full brittleness (T_1 to T_2), and full ductility (above T_2).

NOTE: The above typical curves are reproduced from: FRACTURE AND STRENGTH OF SOLIDS by E. Orowan. Reprinted from REPORTS ON PROGRESS IN PHYSICS, Vol. XII, p. 185, 1949.

measured in hand welded seams, otherwise the stress levels were similar.

Residual stresses in welds have been decreased by block or stepwise welding sequence, and the use of austenitic electrodes also has reduced weld residual stresses slightly, but not enough to offset the cost. In ships, it has been found that the magnitude of locked-in stresses is not materially reduced by the working of the ship at sea.

Thus, since all welded ships contain locked-in stresses, and these stresses are not reduced in service, and since only a fraction of ships suffer casualties, locked-in stresses are not, by themselves, considered the prime cause of ship failures. However, the full role of residual stress in helping to cause failure is not yet fully understood, even though there is evidence to show that stress relief will improve performance of materials in some measure.

b. EFFECT OF CHEMICAL COMPOSITION OF PLATE

It has been found that for steels which are otherwise generally similar, a fully killed steel will have a lower ductile to brittle transition temperature range than a semi-killed steel. Similarly, a semi-killed steel has a lower transition range than a rimming steel. Rimming steels have been used in at least eighteen failure cases, but sufficient data has not been obtained to imply that the use of killed steel will prevent failure.

Table I illustrates the role of individual chemical elements in changing the transition temperature. These tests were made at the Naval Research Laboratories. A base composition of 0.30% C, 1.00% Mn was used in special heats of killed steel. All specimens had a coarse pearlitic macrostructure. Transition temperatures were measured by the intersection of the average energy line with the energy-temperature curve.

One subsequent investigation has found that a high Mn/C ratio is of importance in lowering the transition temperature. In the previously mentioned investigation of fractured ship plates at the Bureau of Standards there was no readily evident relationship between failure incidence and the Mn/C ratio. It was pointed out, however, that only one of the plates had a Mn content higher than 0.60% and that the range and average value of carbon content was higher in each plate thickness group than for non-source plates.

The result of these investigations indicated that the practice of using rimming steels in the past may have contributed to brittle failure in some cases. It also indicated that the practice of using higher carbon steels, either inadvertently, or deliberately to obtain high strength, also may have been contributory. In general, these investigations recommend the use of a high Mn content, but they point out that manganese is one of the most effective single elements in promoting hardenability. Consequently, hardening and cracking can result following welding if the Mn content, in conjunction with the carbon content, is too high. Such cracking can serve to initiate brittle failure. However, another result of the many investigations points out that while composition is important, it is not the sole controlling factor. Brittle fracture has been found to occur in service with a low alloy steel at ambient temperature.

c. MECHANICAL PROPERTIES OF THE FRACTURED SHIP PLATES

Specimens were selected at the Bureau of Standards for the determination of the mechanical properties of the plates, in so far as possible, to represent the properties of the plates as fabricated in the ship. Tension and notched bar tests were run as the criteria for the mechanical properties.

The tension test results indicated that the plates that fractured in service would probably have passed the acceptance tests required at the time of purchase. This investigation divided ship plates into three categories:

1. Source—a plate in which fracture originated.
2. Through—a plate through which a fracture travelled.
3. End—a plate in which a fracture terminated.

The properties determinated from the tension tests of the fractured plates indicated no relation that was sufficiently marked to differentiate between the source, through, or end plates.

The highest value of impact energy for a ship source plate was 11.4 ft-lb at the temperature of failure. Other results of the Charpy V-notch tests showed that of 22 source plates, only two had energies over 10 ft-lb. For end plates, or plates with no fracture, 21 out of 30 had over 10 ft-lb. Further, of 31 plates which were fracture sources only 10% had 15 ft-lb transition temperatures below 70 degrees F. Of 82 plates which did not contain fracture sources, 67% had 15 ft-lb transition temperatures below 70 degrees F.

DISCUSSION

The conclusions of the investigation by M. L. Williams and G. A. Ellinger, both of the National Bureau of Standards, and many other investigators show that the structural failures in welded ships were caused by stress concentrations and by steel that was notch sensitive at the operating temperature.

The most significant of the many observations made by different inspection agencies in the study of ship failure problems have been outlined in this article. These observations indicate that fractures originated in plates of higher than average notch sensitivity at critical locations in the structure and that in at least some cases the inherent notch sensitivity of the plates was further increased, in the vicinity of the fracture, by fabrication operations.

It has been pointed out that the fracture phenomenon is a result of a combination of many factors. There is not yet any practical material which, if used in ships, would totally prevent brittle fractures. Investigators from the Bureau of Standards also point out that there is no test which will surely predict from the behavior of small specimens the performance of a given steel in circumstances where structural brittle fracture might occur.

The general concensus is that there are three principal factors involved in the prevention of failures of welded structures. First, the material should possess, uniformly, the properties anticipated by the designer. These properties should not be adversely affected by the effects of fabrication operations or conditions encountered in service. Second, the designer should aim to produce a structure functionally suitable for the purpose intended. Third, the workmanship or fabrication should carry out the idea of the designer and must produce joints of the strength that he intended. It must be realized that these three factors are somewhat related and by no means tell the whole story. However, their importance cannot be overlooked since fractures in ships usually involve a combination of these three factors.

Because of the fact that a large amount of failures originated in parts that are not ordinarily considered as strength members and propagated through welds into the hull structure, the standards of quality of materials, design, and workmanship for non-strength members that are attached by welding should be equal to those required in the hull structure itself.

CONCLUSIONS

The results of many different investigations have been surveyed and it has been shown that the fracture phenomenon is a result of many factors which have been described in separate sections of this article. The following conclusions can be derived from analysis of the effects of the previously mentioned factors:

1. The brittle type of fracture which is prevalent in all ship failures did not originate in the era of welded construction. Riveted structures also have suffered from the fracture phenomenon with the cracks usually terminating at discontinuities introduced by the riveted joints.
2. It seems probable that in all cases, brittle failure originated at some definite geometrical discontinuity involving design or workmanship.
3. Brittle failure, once initiated, can travel across welds with ease and thus cause more damage in all welded structure.
4. Results of investigations indicate that structural failures in welded ships were caused by stress concentrations and by steel that was notch sensitive at the operating temperatures. This conclusion is confirmed by results of laboratory tests of fractured plates, as well as by critical observations of the starting points and the circumstances of the failures.
5. Residual or locked-in stresses, by themselves, are not the prime cause of ship failure. Also, it has been stated that these stresses are probably not relieved in service. In conjunction with other factors, however, residual stresses, and also thermal stresses, may serve to initiate brittle failure.
6. The effect of chemical composition and metallurgical variables is considered important. Conclusions of investigations indicate that increasing the ferrite grain size, carbon, and phosphorous contents (also certain other elements) and plate thickness will increase susceptibility to brittle fracture. Increase of manganese, and application of normalizing will lower the susceptibility. Killed steel, in general, is less susceptible to brittle fracture than rimmed steel. Other more subtle metallurgical variables are also considered important.
7. Tensile test results of the many investigations indicated that the plates fractured in service would probably have passed the acceptance tests required at the time of purchase.
8. Charpy impact tests generally indicated low values at the failure temperatures.
9. Except in the case of exceptionally poor welds, there is no tendency for cracks to follow welded seams.
10. Age of the ship seems to have no bearing on the failure phenomenon.

The conclusions reached as a result of surveying the many investigations indicate that the three main factors which are of the greatest importance in the prevention of brittle failure in ships are careful design, selection of proper materials, and good workmanship.

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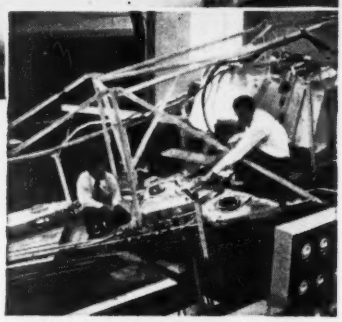

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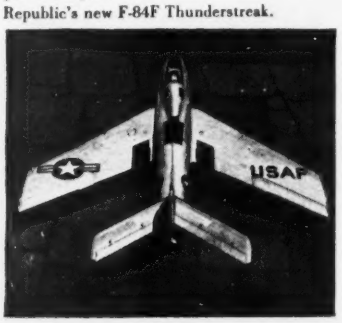

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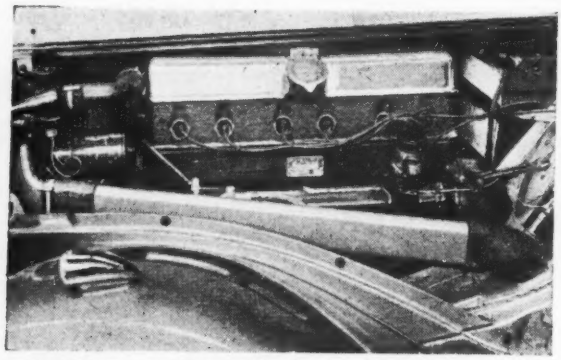
Uncle Karl Drives the Citroen Six

by Karl E. Ludvigsen, '56



The Citroen Six engine fills the long hood impressively.

It is remarkable, in view of the present swell of interest in foreign cars, that one of the most popular and successful of the continental marques is virtually unknown in this country. When it was first introduced in France in 1934, the Citroen was a thoroughly unconventional automobile, and the soundness of this unconventionality has been proven by the fact that the same car, unchanged save for detail alterations, is presently in quantity production in both England and France, while in the latter country purchasers must wait three months before taking delivery. The car clearly must have qualities which appeal to an extraordinarily large number of buyers, and thus it was not without interest and curiosity that I took the wheel of a six-cylinder Citroen supplied by Foreign Motors, Inc., of Boston.

The Citroen is produced in both four and six-cylinder series, both of which use the same bore and stroke and similar construction. Bore is 78 mm. and stroke is 100 mm., giving a displacement of 1911 cc. in the four and 2866 cc. in the six. The latter engine, with which I am chiefly concerned here, gives 76 b.h.p. at 3800 r.p.m., with a conservative compression ratio of 6.2 to 1 and a single Solex twin-choke carburetor. Valves are actuated by pushrods and closed by double valve springs, while the alloy pistons carry four rings. The engine is unusual in that it has removable cast alloy wet cylinder liners, an excellent arrangement for ease of heat transfer and servicing. The method of power transfer, however, is of more interest than the power itself, since the Citroen, like the Dyna-Panhard, uses front wheel drive. The engine and clutch are placed behind the front hub line, and drive the three-speed gearbox, which is ahead of the front axle. Drive to the front wheels is by universally-jointed and splined half shafts. Front suspension is by torsion bar-controlled parallel wishbones, of such lengths that the front wheels undergo changes in both track and camber on deflection, giving a roll center slightly above ground level. Torsion bars are also used at the solid rear axle, which also contributes highly to roll resistance. Another unusual feature for 1934 is integral chassis and body construction. The bodies look, understandably, not unlike those on the 1934 Fords, but the front drive has allowed a much lower overall line and a central seating position for the passengers. The steering is rack and pinion, while the brakes are four-wheel hydraulic.

The driver of the Citroen Six enjoys true chair-height seating, with the non-adjustable steering wheel placed rather high in front of him. The pedals, in accordance with this idea, move more downwards than forwards, and the proximity of the firewall occasionally hinders correct operation of the accelerator. The clutch is stiff, and brakes demand more than usual pressure for effective retardation. The gear lever protrudes from the dashboard at the right of the wheel, and an interlock is provided such that gears cannot be changed unless the clutch is completely depressed. While this arrangement does not prevent such practices as double-clutching (which is not called for by the synchronized gearbox) and fairly rapid shifts, the presence of the interlock and the distant location of the transmission produce a stiff and deliberate, though accurate, action. The suspension can only be described as solid, in the tradition of the car's time of conception, and the independent front suspension is not given free rein. The ride, however, is notable for its lack of pitching and rocking motions, and those road shocks that are transmitted to the body are of such a light, quick nature as to cause no discomfort to the occupants What few vices the ride has are readily forgiven by the fast driver in the light of the excellent handling and cornering qualities of the Citroen. The steering is dead accurate, with two and one quarter turns from lock to lock, just as in the M.G. TD. There is more "road feel" in the steering wheel than in the M.G., however, and the sixty per cent of the car's weight on the front wheels makes steering very heavy at low speeds. When at speed on the road the car becomes more readily responsive, and cornering seems to be a matter of deciding on a given speed for a certain corner and maintaining that speed while guiding the front wheels around the chosen path. The rest of the Citroen simply follows obediently. There is virtually no roll during such maneuvers, and very little protest from the tires, but if the car is held in a fairly sharp bend with a substantial amount of

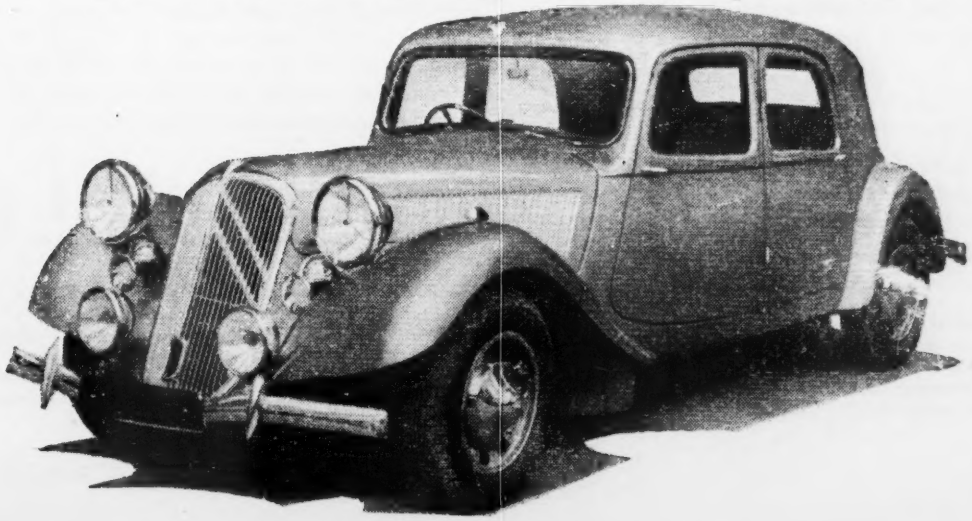
power on, considerable strength is required to maintain the desired course. This, of course, is not encountered in ordinary driving. The usual vice of front wheel drive also exists, in that if the foot is suddenly removed from the accelerator during such a maneuver as that outlined above, a sharp reaction is felt in the wheel and in the front end stability. Again, this only occurs under severer than normal conditions. The front suspension is actually an excellent compromise between a supple arrangement for best front wheel adhesion, and a stiff setup for roll resistance. Combined with this effective cornering ability is the very usable power of the 180 cubic inch engine in a car weighing under 3,000 pounds. The Citroen Six is intended to be particularly flexible in top gear, and this is indeed the case, shifting being unnecessary under all highway conditions. The car can be taken over fifty miles per hour in second gear, however, at which speed the engine remains as steady and silent as it is throughout its speed range. There is a noticeable gear sound at certain speeds, and the overall sound level is similar to that of a Chevrolet. The car will cruise comfortably at seventy miles per hour or slightly higher, as a piston speed of 2,500 feet per minute is not reached until seventy-six miles per hour. With the flexible engine, the tenacious cornering and the steady ride, such a speed can be maintained under the most rigorous conditions.

The Citroen is very much a man's car, and it is difficult to envision a woman driving the Six-cylinder at speed on secondary roads. This is a job for which the car is well fitted, however, but a man is needed at the controls. All aspects of the car are stiff and solid, in the vintage tradition, and it is reasonable to assume a higher than ordinary degree of reliability as a result of twenty years of constant refinement. At all times the Citroen bears out this assumption by its complete freedom from rattles and its steady, precise feel, and it is easy to see, in the light of these endearing qualities, how it has captured such a large and loyal segment of the European market.

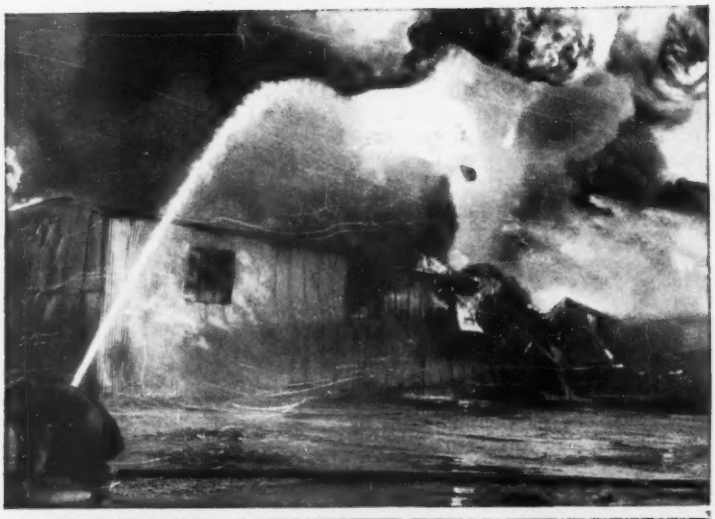
Incidental Intelligence

That irrepressible entrepreneur Bill Vaughan, of Vaughan Motors of New York, has hurled another bombshell into the automotive world in the form of the VSS Sports Coupé, which was introduced at the World Motor Sports Show. The car, white and squat-looking with square openings for round wheels, was hailed as the first American engineered and built sports car, and another placard proclaimed that the VSS would come equipped with left hand drive and bumpers, fitments which were lacking on the model on display. My attitude, of course, was anything but credulous, and after the representative assured me that the very car on display had been built entirely in this country at their plant in Ohio (the location of which cannot as yet be divulged), and that three engines, a 750 c.c. four and two single overhead cam V-eights of 1295 and 1595 c.c. had been specially designed and built for the car, and, finally, that the whole shebang was selling for 2,900 clams, I began to question him on some salient points. The body reeked of Italian design and construction, and after spotting the "Ghia" nameplate on the side I bet him two dollars that it had been built in Italy. He assured me that I would lose my money, and explained that the body was built in this country under Ghia license, and hence the nameplate. When I asked why it had Borrani wire wheels, I was told that those were not Borrani wheels; they just *looked* like them because they were built in this country under Borrani license. I then asked why Italian "Ceat" tires were used on this all-American bomb, and quickly found that Juan Manuel Fangio, who expects to drive the machine soon in European competition and perhaps at Le Mans, prefers Ceat tires and wanted them on the car. In 1952 Fangio's picture appeared in a Pirelli tire advertisement after he had won the World Championship on Pirelli-equipped Alfa Romeos, and he is known to have signed a contract to drive for Lancia this year, but this may be extraneous information. Finally, in answer to another query, I was told that the reason this American-built car had right-hand drive was so that people like me would ask if left-hand drive was available. This sounded reasonable to me, so I took my leave, after receiving a bit of strictly confidential information. Tell me, did you know that the complete Cadillac and Chrysler lines for 1954 were designed by the Ghia firm in Italy? Well, you learn something new every day.

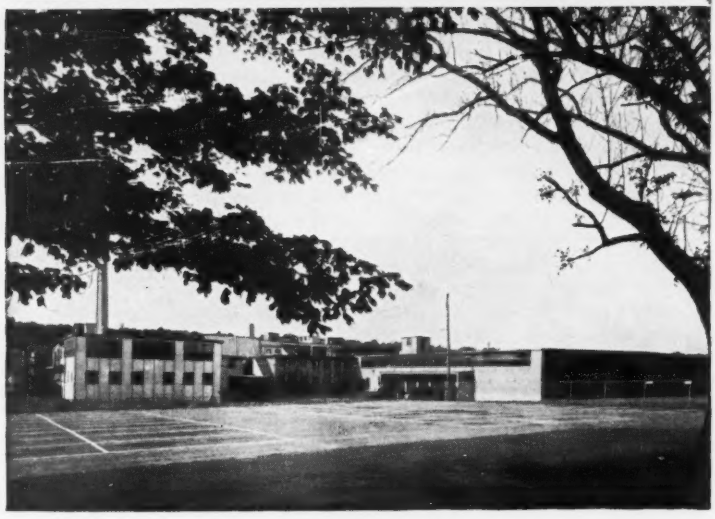
The lines of the Citroen have not changed appreciably from this pre-war example.



Height of the **fire**



at **two** chemical plants



One plant is a seething inferno. Several persons were injured in this mid-western chemical plant fire, which resulted in a $600,000 loss.

How different the story at the other chemical plant. When fire broke out at Arnold Hoffman & Company, Inc., Dighton, Mass., there was no rapid spread of flames. No one was injured. The blaze was confined to a single area of the plant and the damage was negligible.

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PROGRESS OF A PROBLEM

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Aircraft shown in the accompanying photographs are among those equipped with Hughes radar and fire control systems.

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the magnetic amplifier

by Peter Schultz, '55

The magnetic amplifier has been known and has seen limited use for at least twenty-five years. However, like many other engineering developments, its full potentialities were not explored until the pressures of the Second World War gave a new incentive to scientific research and technological developments. During the war, much work was done on magnetic amplifiers in Sweden and Germany. In addition, a considerable amount of work was done in Great Britain and America. Today the magnetic amplifier is a device that has a large number of uses with lots of room for additional applications.

The magnetic amplifier is a device which makes it possible to control a large current flowing in one part of a circuit with the variations of a relatively small current flowing in another part. This can be thought of as analogous to a vacuum tube amplifier which controls a relatively large voltage in one part of the amplifier circuit with the variations of a much smaller voltage in another part of the circuit. Thus the magnetic amplifier deserves to be classed as a control device along with the vacuum tube, transistor, variac and mechanical valve.

The operation of the basic magnetic amplifier circuit depends on the fact that the hysteresis loop or, flux-linkage vs. ampere-turns curve, for magnetic materials such as iron or steel is nonlinear. The permeability of a wire-wound magnetic core material depends on the number of ampere-turns applied to it and is proportional to the slope of its hysteresis loop at the point on the loop corresponding to the number of applied ampere-turns. But the inductance is proportional to the permeability of the core and therefore the impedance of the windings depends on the permeability of the core. As one can see from inspection of the hysteresis loop, the slope at point A and therefore the permeability at A is much greater than at point C. Therefore the impedance of the inductor when NI_a ampere-turns are applied to it is greater than when NI_c ampere-turns are applied. Here we have the principle on which the magnetic amplifier works—the fact that the impedance of a wire-wound magnetic core will change as the current flowing through the wire changes.

Now let's consider the elementary circuit of a magnetic amplifier.
As far as the AC circuit is concerned, the core acts as an inductor with a variable inductance. The inductance is varied by changing the current

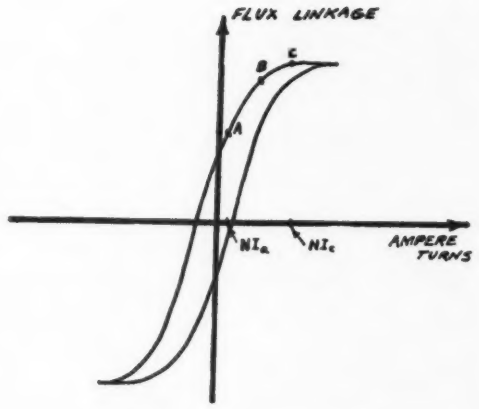

Fig I. TYPICAL HYSTERESIS LOOP

in the control circuit. If the DC control current is small, then the permeability of the core will be relatively large and the inductance of the AC windings on the core will be large. The impedance in the AC circuit will be large and a small AC current will flow through the load. If we increase the control current the permeability of the core will decrease and so will the inductance. If the control current is increased enough, the inductance will become almost negligible. Therefore the total impedance of the AC circuit decreases and the AC current increases. In this way we can control the AC current by varying the DC current in the control circuit.

Instead of one set of control windings, two can be used as shown in Figure 2. The bias windings or what one might call the bias circuit is arranged so that a fixed current flows and this current fixes the inductance of the core in the AC circuit in the manner explained previously. The bias windings in the control circuit are analagous to the grid bias voltage or "C" battery in a vacuum tube amplifier. In a vacuum tube amplifier, the grid bias fixes the operating point of the tube. Likewise, the current in the bias windings can be considered as fixing the "operating point" or AC inductance of the core with no control current.

In addition to the bias windings there is also another set of windings in the control circuit to which a DC "signal" or small DC control current is applied. The bias winding current is set so that the "operating point" of the core is near a point

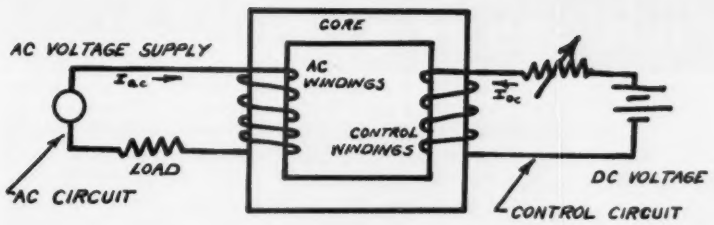

Fig. 2 BASIC MAGNETIC AMPLIFIER CIRCUIT

such as point B in Figure 1. Point B is a point where the permeability and inductance are still rather large, but where a small increase in the control current applied to the control windings will greatly decrease the permeability and inductance and therefore increase the AC current through the load. Since the load current is usually taken as the output, small changes in the input current cause larger changes in the output current of a magnetic amplifier. Current is the quantity amplified in the magnetic amplifier.

Several modifications of the basic magnetic amplifier circuit shown in Figure 3 are possible. One modification is called a self-saturating circuit. In this circuit, the half-wave rectifier permits current to flow in only one direction in the AC circuit. This rectification of AC current gives rise to "pulsating current" in the load and through the AC windings on the core. This pulsating current has a DC component which will affect the core in the same way as the bias windings affect the core in Figure 3. Hence the bias windings are no longer needed and only the input signal windings are left in the control circuit. This is somewhat analogous to eliminating the grid bias or "C" battery in a vacuum tube amplifier by means of a cathode resistor in parallel with a "by-pass" capacitor.

In some applications, a DC current through the load may be desired instead of the usual AC current. This can be accomplished by a circuit similar to that in Figure 5, by using a bridge-type full-wave rectifier circuit. Similarly, the control current may be a rectified AC current.

Under some conditions it is advisable to introduce feedback into a magnetic amplifier circuit. Feedback means feeding part of the output quantity (in this case current) back into the input. In a magnetic amplifier this usually means rectifying the load current and sending it through some windings on the core. One way of doing this is shown in Figure 6. Feedback can be either positive or regenerative where the feedback windings produce core flux in the same direction as the flux produced by the control signal windings or it can be negative or degenerative where the core flux produced

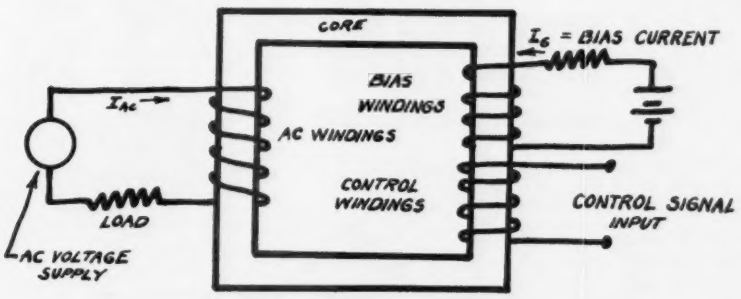

FIG. 3 MAGNETIC AMPLIFIER WITH BIAS WINDINGS

To be a successful engineer, above all you must know how to cut costs

SIMPLE DESIGN CHANGE TO STEEL CUTS COST FROM $1.15 TO 31¢

BEFORE any product design is accepted, the manufacturer asks, "Can it be built for less money?" Unless your designs pass this test they are likely to be rejected.

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Here, for example, is how one resourceful engineer put these qualities to work:

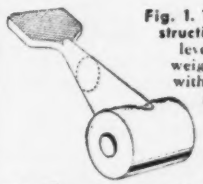

Fig. 1. Traditional Construction. Machine foot-lever, 10 inches long, weighs 6 pounds. Cost with broached keyway is $1.15.

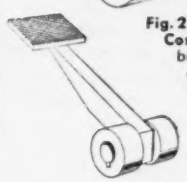

Fig. 2. Simple Steel Design Costs 41% Less. Can be built by the shop with only saw and shears. Weighs 2.7 pounds. Costs 68¢ complete with keyway.

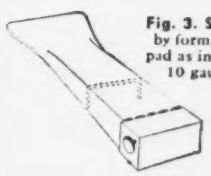

Fig. 3. Saves 53% Cost by forming lever arm and pad as integral piece from 10 gauge metal. Weighs 2.5 pounds. Costs 54¢.

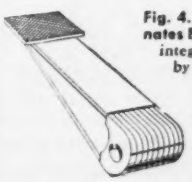

Fig. 4. Saves 73%, Eliminates Broaching. Hub with integral key is produced by stacking stampings in assembly. Arm is 10 gauge, brake formed and welded to hub. Cost is only 31¢. Weighs 2.2 pounds.

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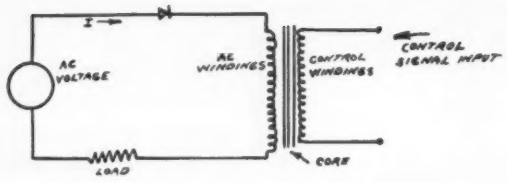

FIG 4 A SIMPLIFIED SELF-SATURATING CIRCUIT

by the feedback windings opposes that produced by the control signal windings. Positive feedback increases the current gain of the magnetic amplifier, but it also increases the response time or the time in which it takes the device to respond to a given control signal. If too much feedback is applied, the magnetic amplifier will become unstable and the control signal will lose control over the load current. On the other hand, negative feedback tends to produce a more linear response, to shorten the response time and to make the magnetic amplifier more stable. However, it also decreases the current gain. By means of feedback, the response time and current gain of a magnetic amplifier can be varied, although they cannot be varied independently of each other.

When compared with electronic amplifiers such as vacuum tube or transistor amplifiers, the magnetic amplifier has both advantages and disadvantages. Its main advantage over electronic amplifiers is its ruggedness. In the magnetic amplifier there are no glass envelopes of tubes to break and no delicate tube innards to fail to work under shocks and stresses. Also, most magnetic amplifiers will be operative within five cycles after the AC voltage is connected into the circuit, but in vacuum tube amplifier one must allow what is often a considerable amount of time for the filaments to heat. This gives the magnetic amplifier what is called a lower stand-by power ratio than the vacuum tube amplifier. Another conspicuous advantage of the magnetic amplifier is that it is very easy to add or subtract input signals simultaneously. This is done by having several DC control signal inputs to the core. The useful life of the magnetic amplifier is much greater than the life of an electronic amplifier. This is because vacuum tubes and transistors have relatively short operational lives when compared with magnetic materials.

Like most other things, the magnetic amplifier also has some disadvantages. The main one is its relatively slow response. A response time of one-tenth of a second is considered good with the present models. This is for power frequency (25 cps to 120 cps) AC voltages. Tests performed indicate that the response time tends to decrease as the frequency of the AC supply voltage is increased. The apparently obvious thing to do to improve the response time is to increase the frequency of the AC supply voltage. However, this is not always feasible because AC power is often available only at power frequencies such as 60 cps. Some magnetic amplifiers have been designed to provide power gains as large as 100,000. However, in a magnetic amplifier the ratio of gain to response time is pretty much constant. Therefore, as the gain is increased the response time is increased and vice versa. Also, in a magnetic amplifier any kind of feedback will decrease the power available at the output. Serious design and production difficulties are encountered since the core materials are not easily produced within the necessary tolerances. When compared with the electronic amplifier, the magnetic amplifier is a heavy and bulky object.

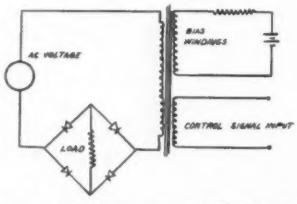

FIG 5 MAGNETIC AMPLIFIER CIRCUIT THAT GIVES DC CURRENT THROUGH LOAD

With these advantages and disadvantages considered, the magnetic amplifier has many uses. It is used wherever it is necessary to amplify a weak DC signal and where immunity from shock and wide temperature variations are important. For example, magnetic amplifiers are frequently used to control rolling mills and artillery and as measuring devices in rolling mills and other places where tremendous shocks are present. They are often used in theaters to dim lights gradually. In industry they are used frequently to control and to provide either DC or AC excitation for electric motors and other machinery. They are often used in servo-controls in guided missiles and aircraft. Also they have been used in the trigger mechanism of magnetic mines. Quite often they are used in circuits with photo-sensitive devices. When light shines on a photo-tube, the tube current increases. This tube current is fed into the control windings of a magnetic amplifier and an amplified signal appears at the output. This amplified signal may be used to actuate a relay, ring a bell or control a motor. These are a few of the present applications of the magnetic amplifier, a device which is just coming into its own and with which much experimental and development work is now being done.

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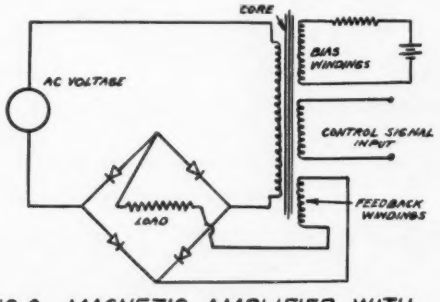
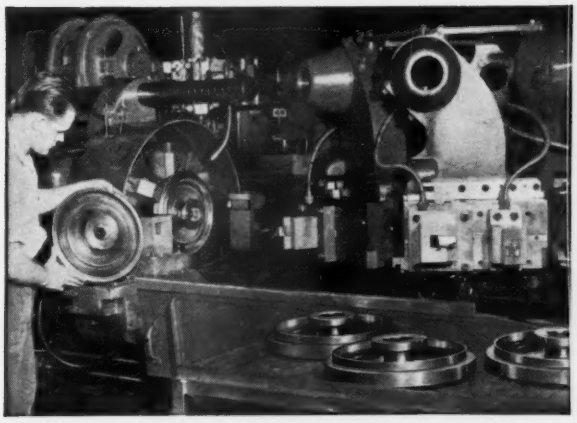


FIG 6. MAGNETIC AMPLIFIER WITH FEEDBACK

Another page for **YOUR BEARING NOTEBOOK**



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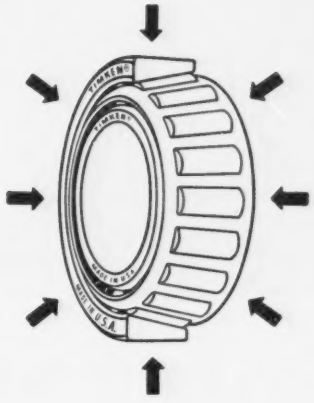

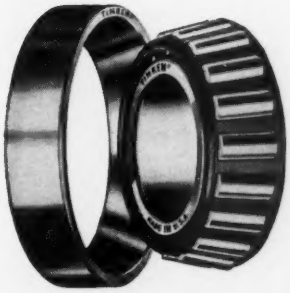

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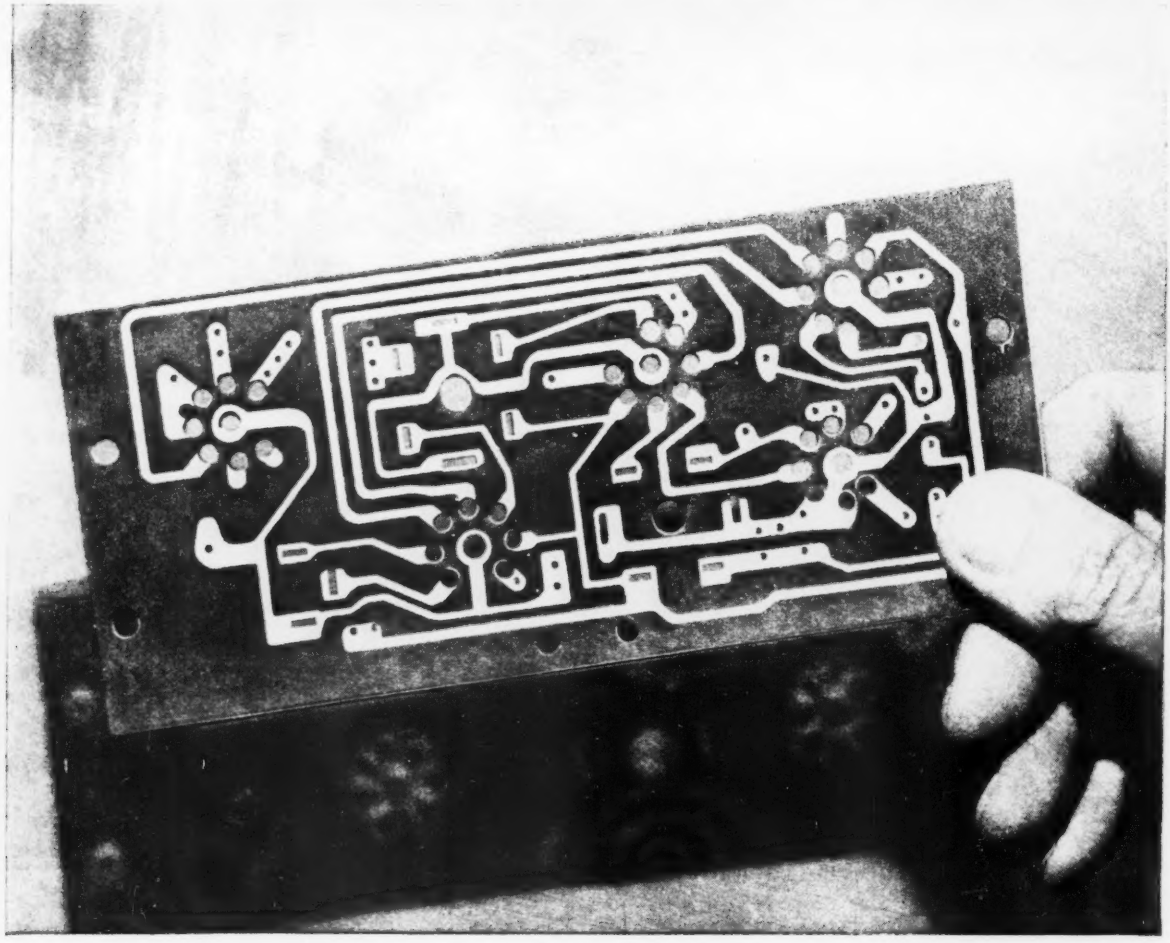
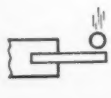


Pattern of things to come

IN ADDITION TO THE PROPERTIES ALREADY MENTIONED IN THE ADVERTISEMENT, SYNTHANE HAS



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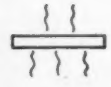

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For years radio sets were put together by laboriously soldering a forest of wires to terminals. It was a time-consuming and expensive operation. If one connection proved faulty, the whole assembly had to be rechecked.

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The printed circuit is still in development—but it has zoomed into favor for radio, TV, hearing aids, and many other electronic devices. There are now a dozen ways to produce what are still called "printed" circuits. And Synthane is an accepted base material for every one of them.

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chocolate bars, burglars, and bessel functions

by David Sternlight, '54

Of the many electronic phenomena with which the modern layman is acquainted, the "electric eye" is perhaps the most mystifying. Light is a powerful tool in many ways, but this article will only consider the part that it plays in the photo-electric effect. Let us examine, then, several ingenious devices involving a beam of light and a photocell. Those who attend the Institute are very familiar with one labor-saving device of this kind: the automatic doors at the Massachusetts Avenue entrance to the Building Seven lobby. The doors are opened when a light beam is broken by an opaque object. A similar device is used in industry to count chocolate bars and other small articles. As the bars pass down the production line they interrupt a beam of light, causing a photocell to activate a counter. Many industrial safety devices use this principle to keep a worker's hands out of a dangerous area before a punch press, for example, will operate. Height gauges for industrial quality control also employ a controlled beam of light. In this case, two light beams are used, with two photocells. The first beam of light is at the correct height, plus a tolerance. The second is at the correct height minus the tolerance. If the object is within the tolerance limits, the high beam continues to activate a photocell and relay, but the low beam does not. If the object is too high, the high beam is interrupted and the object is rejected. A reject also occurs when the object is too short, and the lower beam then strikes the photocell (See figure 1).

One of the most interesting applications of the photocell principle is in the design of burglar alarms. Perhaps the most ingenious alarm of this kind ever devised works as follows. The basic principle is the interruption of a light beam, but there are several problems. First, a large area must be covered. Secondly, the burglar must not know the alarm exists. Thirdly, he must not be able to foil it even if he knows of its existence. It is possible to pass through a beam of light without tripping a photocell by carrying two flashlights and shining them along the beam in opposite directions. One of them will hit the photocell and keep it activated while you pass through the beam. The photocell cannot tell the difference between your beam of light and the one usually trained on it. The alarm described here, a commercial product, has the following ingenious features. The beam is routed around the protected area by a system of mirrors, and does not reach the photocell until it has crossed the area several times (See figure 2.). This beam, if interrupted anywhere, will trip the alarm. The second feature of this clever device is that it uses infra-red light. This light is invisible to man, but photocells are available with a great deal of sensitivity in this region of the spectrum. As a matter of fact, during World War Two the army attached to their rifles, a "Sniperscope" which utilized an infra-red beam and photo-electric viewing method to maintain the effectiveness of our riflemen even at night. A burglar cannot see this beam; yet if he is an employee of the concern he can use a flashlight with an infra-red filter to foil the alarm. This is where the third and most ingenious feature of this system comes in. Before being sent out, the infra-red light beam is interrupted at a predetermined variable freguency by a rotating wheel. The receiving unit is synchronized with this frequency, and any other light beam is ignored. The burglar cannot conveniently duplicate this varying frequency, and so is foiled completely. A final safety measure is that if any wires are cut or any power turned off, the alarm goes off automatically. In the battle of science against crime, it would seem that the burglar hasn't a fighting chance. With the addition of electrical door locks, the burglar can be trapped and held prisoner until the police arrive.

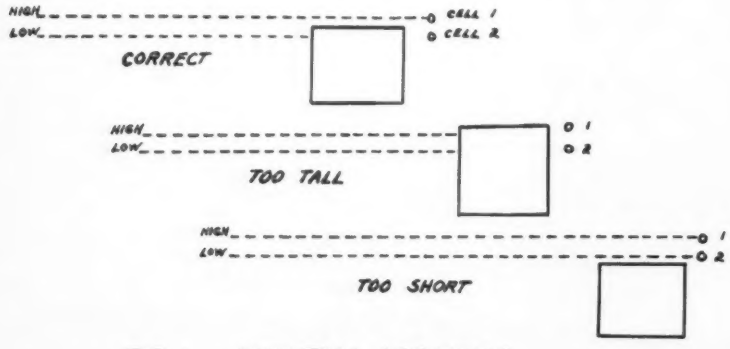


FIG 1. HOW TALL ARE YOU?

What has all this to do with Bessel functions? The answer is simple. Most digital computers use punched paper tape to assimilate information. This tape is opaque, and the tape reader has a light source above the tape and holes below the tape, each with a corresponding photocell. When a hole in the tape co-incides with a hole in the reader, the photocell associated with the hole is energized, and puts out a pulse of electricity. This sort of

(Continued on page 36)

electro optical image processing

National Bureau of Standards

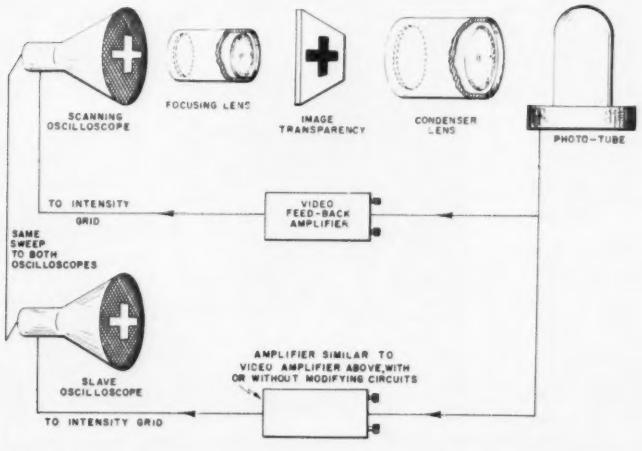
The National Bureau of Standards has recently constructed an experimental optico-electronic system that will facilitate the study of visual perception and recognition of patterns and also promises to have a number of useful engineering applications. This device can clarify blurred images or produce outline pictures, line drawings, from half tone photographs., Other possible applications include the automatic recognition of patterns such as fingerprints or biological specimens. The project was conducted as part of the NBS basic instrumentation program which is sponsored by the Office of Naval Research, the Office of Air Research, and the Atomic Energy Commission.

In the study of visual processes it is necessary to have mechanisms available which can manipulate or process images in any manner, so that the postulated mechanisms of the human brain can be approximated. For example, in the study of the recollection of patterns such a device should be able to modify a two-dimensional pattern in various predetermined ways analogous to assumed or observed processes of actual visual memory. To some extent "trick" photographic methods can be used for these purposes, but they lack the inherent rapidity, sensitivity, and flexibility which the Bureau's optico-electronic system provides.

The system operates on patterns in the form of photographic transparencies placed in an optical assembly between a cathode-ray tube with a moving spot and a photo-multiplier tube. The signals resulting from scanning the picture are amplified and fed back to the intensity control of the cathode-ray tube and, thus, produce a picture on its screen.

The negative feedback obtained in this way improves the tonal rendition of the picture. The same signals are also applied to another amplifier and the resulting signal is used to control the picture. Altering the monitor for the image monitor cathode-ray tube which reproduces the processing is accomplished by introducing modifying circuits between the phototube and the monitor. This freedom to modify the picture on the monitor is the essence of the system.

Any scanning pattern may be used, but it greatly simplifies the electronic circuits if the scanning velocity is the same in two orthogonal directions. The NBS system achieves this type of scan by applying triangular waves to the horizontal deflection of the scanner and a slightly different frequency wave of the same type to the vertical deflection. The result is a Lissajous figure of rectangular shape that changes its proportions with the instantaneous phase between the two waves. The same waves are applied to the monitor for identical scanning.



Block diagram of NBS scanning equipment. A moving spot on the cathode-ray tube scanner is focused on the transparency. The light through the transparency impinges on the phototube which converts the changes in light intensity into electrical signals. These video signals are amplified and applied to the scanning tube intensity grid, thus reducing the light intensity of the spot and producing a negative picture on the scanning tube screen. The same video signals are modified and displayed on a monitor cathode-ray tube oscilloscope.

This image processing system has so far been employed in the study of the enhancement of contours in photographs and to the production of outline pictures from half tone photographs. The process of contour enhancement is essentially that of increasing the abruptness of tone transition at contour lines. A similar phenomenon occurs in the "brightness contrast" in human vision. If a dark area is adjacent to a light area, the dark appears darker and the light appears lighter close to the boundary. For example, the apparent gradation of tone across an individual bar in a stepped gray scale is an illusion, which can easily be verified by covering all but one bar.

The sharpening of tone transitions for contour enhancement is accomplished by modifying the waveform of the signal applied to the monitor oscilloscope.

(Continued on page 36)

chocolate bars,

(Continued from page 34)

reader is capable of the amazing speeds and accuracy necessary for high speed computer input. In our own Whirlwind I a new reader has been installed recently, made by the Ferranti Electric Company of England. This reader seems to be very reliable, and can start and stop in about one sixteenth of an inch of tape.

Many more uses for optical sensing with photocells are only waiting on man's ingenuity. The television camera itself is merely an elaborate photocell. A low cost industrial television camera has been introduced by RCA for closed circuit work. Called the "TV Eye", it places television on a closed circuit basis within the reach of even the most modest budget, since it sells for well under 1100 dollars. The experimenter can build for well under five dollars, photocell and associated circuits which afford many fascinating hours of gadgeteering. Circuits can be found in almost any radio or electronics magazine. There are many ideas available, ranging from the simple "daylight alarm" for fishing trips, where rainy weather is a good excuse for sleeping late, to the more complicated "modulated light beam" presented by General Electric at the World's Fair. This makes possible point-to-point communication via a beam of light; a form of super microwave arrangement. The photo-electric cell is certainly one of the most versatile tools of the modern scientist.

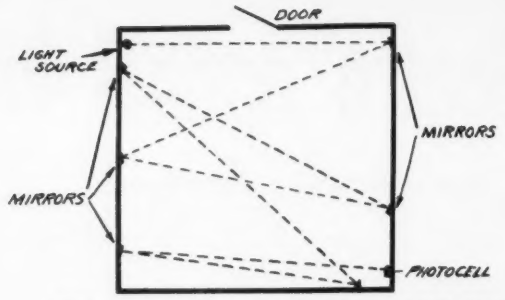


FIG 2. IT'S DONE WITH MIRRORS

electro optical

(Continued from page 35)

This is done by electrically adding an enhancing signal (the negative of the second derivative) derived from the original signal. Mathematical analysis of the process indicates that a first approximation to a correctly focussed picture is obtained when this process is applied to an incorrectly focussed picture. Used in this way, the system is a two-dimensional (visual) analogue of a high frequency compensated audio system.

The formation of outline pictures from photographic negatives is accomplished by using different modifying signals. If the signals from a differentiating network are rectified, a positive pulse is obtained as the light spot passes over a region of sharp tone gradient. The application of such signals to the intensity control of the monitor results in pictures that show only the contour lines, like line drawings.

This outlining process may be used for automatic production of sketch maps from terrain photographs or the display of contours on X-ray pictures or coronagraphs. In picture transmission where line drawings are acceptable, economies in bandwidth are possible through reduction in the information that must be transmitted. Also, contrast enhancement may be used in television to reduce the effects of low transmission bandwidth. The suggestion has been made that the system would be useful in the field of analogue computers as an aid to the solution of some types of differential equations.

The convenience and rapidity with which the position of the picture on the tube screen can be manipulated, as well as the possibility of scale changes in any direction, may permit automatic recognition of patterns by auto-correlation techniques. The use of outlining may facilitate this process.

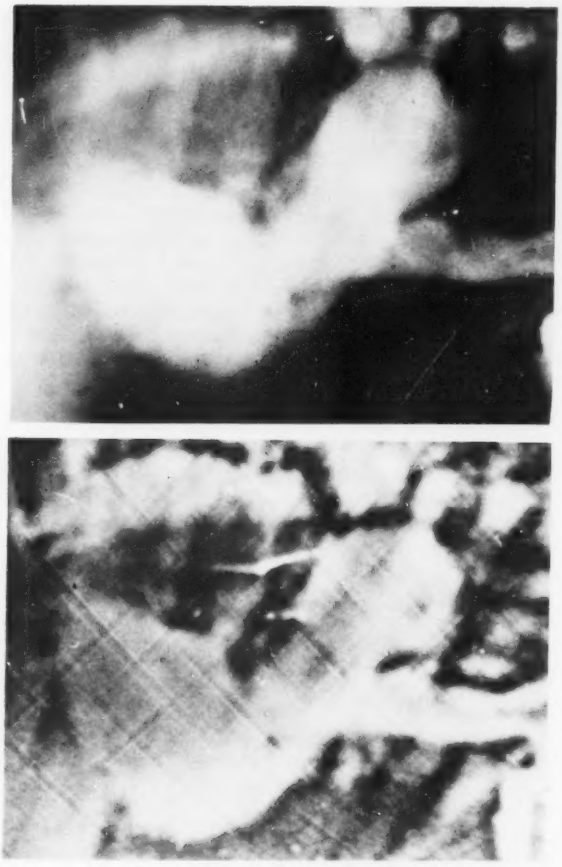


Figure 2. At the top is a picture printed directly from a negative of an X-ray photograph of the human heart. At the bottom is the result of the contrast enhancement process. Both photographs are positive of the original radiograph.

Brig. General David Sarnoff, Chairman of the Board, Radio Corporation of America

Sees No. 1 wish come true!

Television Tape Recording by RCA Opens New Era of Electronic Photography

In 1956, RCA's General Sarnoff will celebrate his 50th year in the field of radio. Looking ahead to that occasion, three years ago, he asked his family of scientists and researchers for three gifts to mark that anniversary: (1) A television tape recorder, (2) An electronic air conditioner, (3) A true amplifier of light.

Gift No. 1—the video tape recorder—has already been successfully demonstrated, two years ahead of time! Both color and black-and-white TV pictures were instantly recorded without any photographic development or processing.

You can imagine the future importance of this development to television broadcasting, to motion pictures, education, industry and national defense. And you can see its entertainment value to you, in your own home. There the tape equipment could be used for home movies, and—by connecting it to your television set—you could make personal recordings of your favorite TV programs.

Expressing his gratitude for this "gift," Gen. Sarnoff said it was only a matter of time, perhaps two years, before the finishing touches would bring this recording system to commercial reality. He described it as the first major step into an era of "electronic photography."

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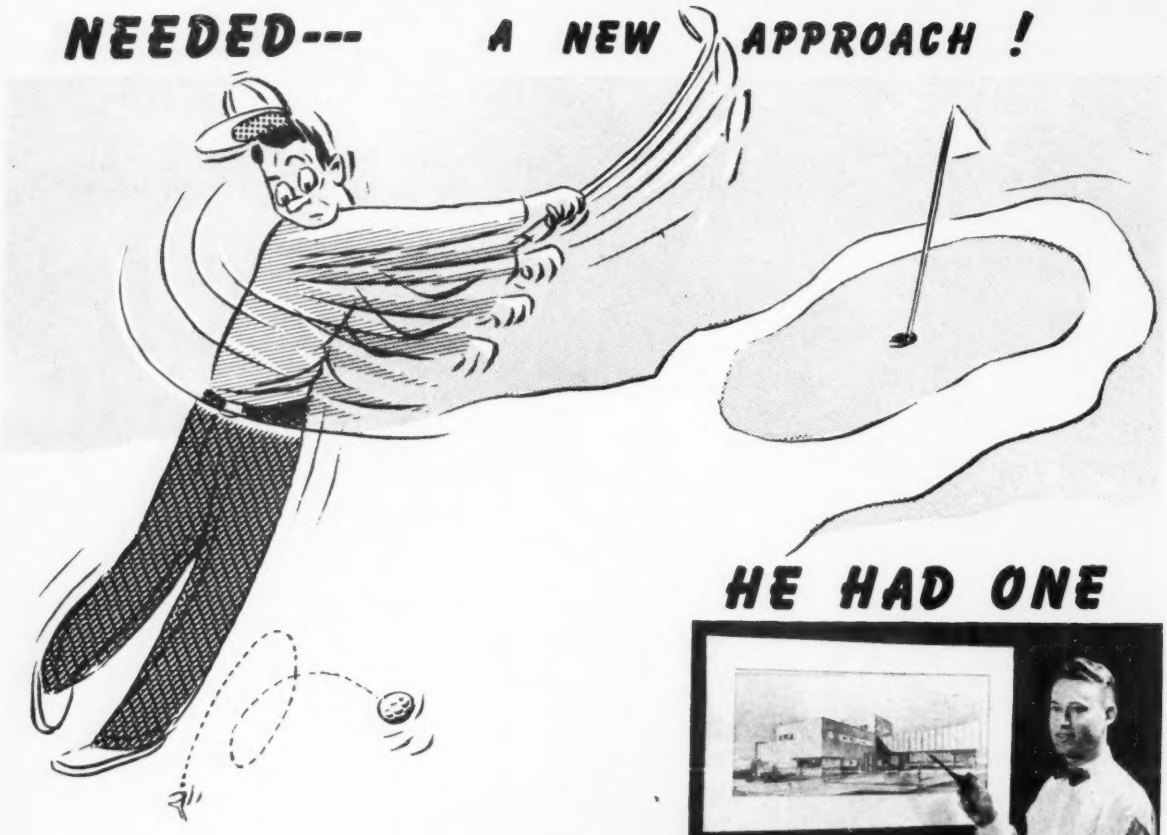
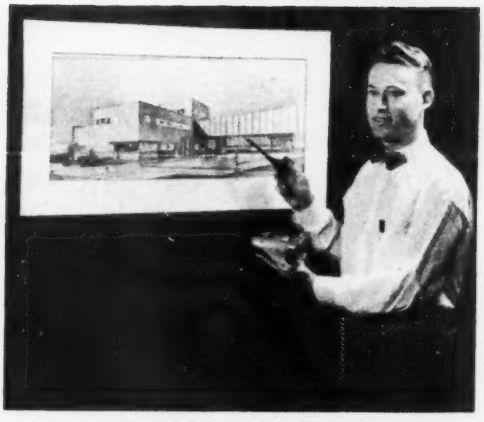


HE HAD ONE



LAMAR A. RAMOS, JR.,
Sr. Design Engineer—Airplane Engineering Division
B.S.P.E. Lousiana State U. 1941
B.S.A.E. Georgia Inst. of Technology 1947

Seen here examining the architect's sketch of our recently completed Wind Tunnel, Lamar's approach in solving complex and often unique aerodynamic problems has marked him as an engineering asset to M.A.C.

In 1947, he was first assigned to the XF-85 "Parasite" fighter, model of which he is holding above, and has since contributed his aerodynamic talents to most of our airplane engineering projects. He is presently a Group Leader concerned with the aerodynamic design of aircraft proposals. We need more young engineers like Lamar Ramos, *engineers with a new approach.*

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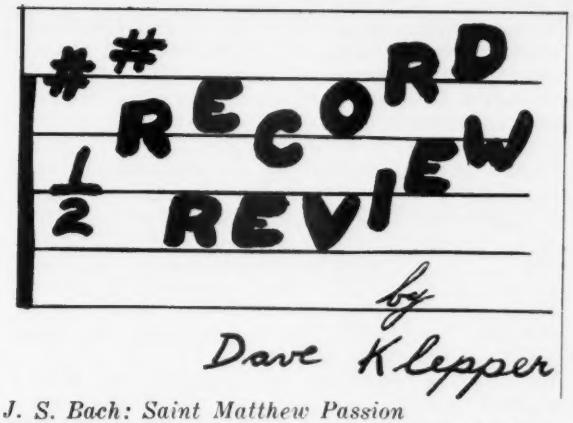


J. S. Bach: Saint Matthew Passion
Willem Mengelberg conducting the Amsterdam Concertgebouw Orchestra, the Amsterdam Toonkustchoir, the boys choir "Zanglust" and the following soloists: Karl Erb, tenor (Evangelist); William Ravelli, bass (Christ), Jo Vincent, soprano; Ilona Durigo, alto; Luis van Tulder, tenor; Herman Schey, bass. Columbia SL-179, three 12", $17.85.

Approx. 150 min.

Hermann Scherchen conducting Orchestra and Chorus, and the following soloists: Hugues Cuenod, tenor (Evangelist); Heinz Rehfuss, bass (Jesus); Magda Laszlo, soprano; Hildegarde Roessel-Majdan, contralto; Petre Munteanu, tenor; Richard Standen, bass.
Westminster WAL 401, four 12", $23.80.

Approx. 180 min.

One of the most important events of LP recording occurred when three recording companies each released a new Bach *St. Matthew Passion.* Only two were available to this reviewer, the Columbia and Westminster; these will be discussed here. I've tried to make up for my obvious lack of background by thoroughness in comparing the recordings section by section, following the complete score, and have learned much about the work not available to me just through repeated listening. I've heard portions of the older Vox recording, for a long time the only LP set available, and I'll occasionally refer to it.

Both Scherchen and Mengelberg have definite, and perfectly valid, ideas on the performance of this work; these ideas have different value in each section. The only method I can adopt in guiding the reader as to which of the two recordings will best satisfy his prejudices is to take him through the comparisons I made in the more important sections, then summarizing the recordings in their total effects.

In the opening chorus there is a marked difference. The listener is immediately aware of Mengelberg's wonderful attention to detail and dynamics; the expression is beautiful, although Mengelberg's characteristic irregularity of tempo may mar the effect for some. Scherchen rushes through this section at a speed that leaves no time for expression; and the beautiful and dramatic sonority of the Amsterdam Toonkustchoir is opposed by a very restrained chorus for Dr. Scherchen. The straightforward, yet expressive performance of this section on the Lehmann recording is worth listening to. The first recitative provides Karl Erb, Mengelberg's Evangelist, an opportunity to show his superiority. The first Alto aria "Rus und Reu" ("Grief and Sin") present difficulties in both recordings, Scherchen's speed being as infuriating as Mengelberg's tampering with tempo in each measure. Here, as in the following aria for soprano, "Blute Nur" ("Break and Die") the performance on the old Vox Lehmann disks is most appealing, although Mengelberg's varying tempos seem to make a little more sense in the soprano aria. Despite more dramatic expression from the Mengelberg, the vocal quartet "Ich Bin's" is most effective on the Westminster. The soprano aria "Ich Will Dir mein Herze Schenken" ("Jesus, Savior, I am thine"), with the beautiful oboe d'amore part is done so well in both recordings, despite the characteristic varying Mengelberg tempo, that I could not make up my mind if I did not prefer Magda Laszlo's voice on the Westminster.

The famed St. Matthew chorale first appears as "Erkenne Mich" ("Receive me"); at this point Scherchen's tempo is slow enough to allow considerable expression, and the restraint of his chorus is preferred. His taking the second appearance of the chorale (the only time it is repeated exactly, without change of key and variation) at a slower pace than the original statement provides a good clue to his concept of the total work; it is again very beautiful. Mengelberg omits this section "Ich will hier" ("Here would I stand"). Also left out from the Columbia recording is the beautiful Bass aria "Gern will mich bequemen" ("What trials await me here"), again beautifully performed in the Westminster.

Once again Scherchen seems too fast to this reviewer in "So ist mein Jesus nun gefangen" ("Behold, my Savior now is taken"), and the punctuations by the chorus, "Last ihn, haltet, bindet nicht!" ("Loose Him! Leave Him! Bind Him not!"), are a pale shadow of the dramatic commands uttered by Mengelberg's chorus. I was very tempted to shove the gain way up, then back down, to release the chorus from the restraints imposed upon it either by Scherchen or the recording engineers. This portion of the Passion, where Jesus is taken by Pilate's soldiers in the garden of Gethsemane is in itself a most important dramatic incident and ought to sound like it! However, in the following "Sind Blitze, sind Donner in Wolken verschwunden?" ("Have lightnings and thunders their fury forgotten?") Scherchen's speed is his greatest asset for dramatic impact.

The Westminster recording continually features a contrast between the rougher voice of Hugues Ceunod, the Evangelist, and the very sweet voice of Heinz Rehfuss, Jesus; this is well illustrated in the recitative "Und siehe, Einer aus dene" ("And behold, one of them that were with Jesus"). Karl Erb's voice seems too beautiful in describing how "one of them" struck a servant of the high priest, taking off his ear; Ceunod's roughness seems more appropriate. Mengelberg loses much of the beauty of the final chorale of the first portion of the Passion by using the boys' choir where not specified in the score. His performance would otherwise be as beautiful as that

given by the here suitably restrained chorus in the Scherchen recording.

In the opening section of Part II the beautiful alto aria "Ach! Nun ist mein Jesus hin!" ("Alas! Now is my Savior gone!") is followed by a very dramatic "Wo ist Denn dein Freund hingegangen" ("Whither is thy beloved gone?")—when heard on the Mengelberg recording. Scherchen, however, has a more dramatic "Weissage uns Christe, wer ist's der dich schlug?" ("Now tell us, Thou Christ, who is he that smote Thee?"), although "Er ist des Todes schuldig" ("He is worthy of death!") is louder, therefore better, with Mengelberg.

Part II shows many cuts in the Mengelberg performance; none seriously reduce the dramatic continuity, but much beautiful music is lost. Some of the drama is left out by cuts preceding the point where Pilate asks the Jews whether they would prefer Jesus or Barabbas be set free. The response by the chorus "Barrabam!" is another place where turning up the volume sharply improves the Westminster, almost to the emotional response evoked by Mengelberg.

The lyrical performance by Scherchen's chorus of "Wie wunderbarlich ist doch diese Strafe!" ("Oh wond'rous love, that suffers this correction!") is one of the finest pieces of choral singing I've heard. We can, after hearing this, review the progression of variations of the basic St. Matthew chorale. Mengelberg adopts nearly the same, rather slow, tempo for each example of the chorale; but they are progressively softer, until, with "O Haupt, voll Blut und Wunden" ("O sacred head sore wounded"), the chorus sings with a softness that Scherchen's chorus never attains. This serves as a framework for Mengelberg's emphasis of Part I. Scherchen, however, wishes to emphasize Part II; he conducts the chorales progressively slower, until they reach the majestic proportions of Mengelberg's performances in Part I.

"Eli, Eli, lama sabachtani," Jesus on the cross, and the Evangelist's translation ("My God, My God, why hast thou forsaken me?") are given different treatments. In the Mengelberg recording the sweet voice of Jesus is opposed by a painful cry from Karl Erb, the Evangelist; but, in the Scherchen, Hugues Cuenod adopts the sweet tone of Jesus, only while he is directly translating Jesus' words. Both are highly moving.

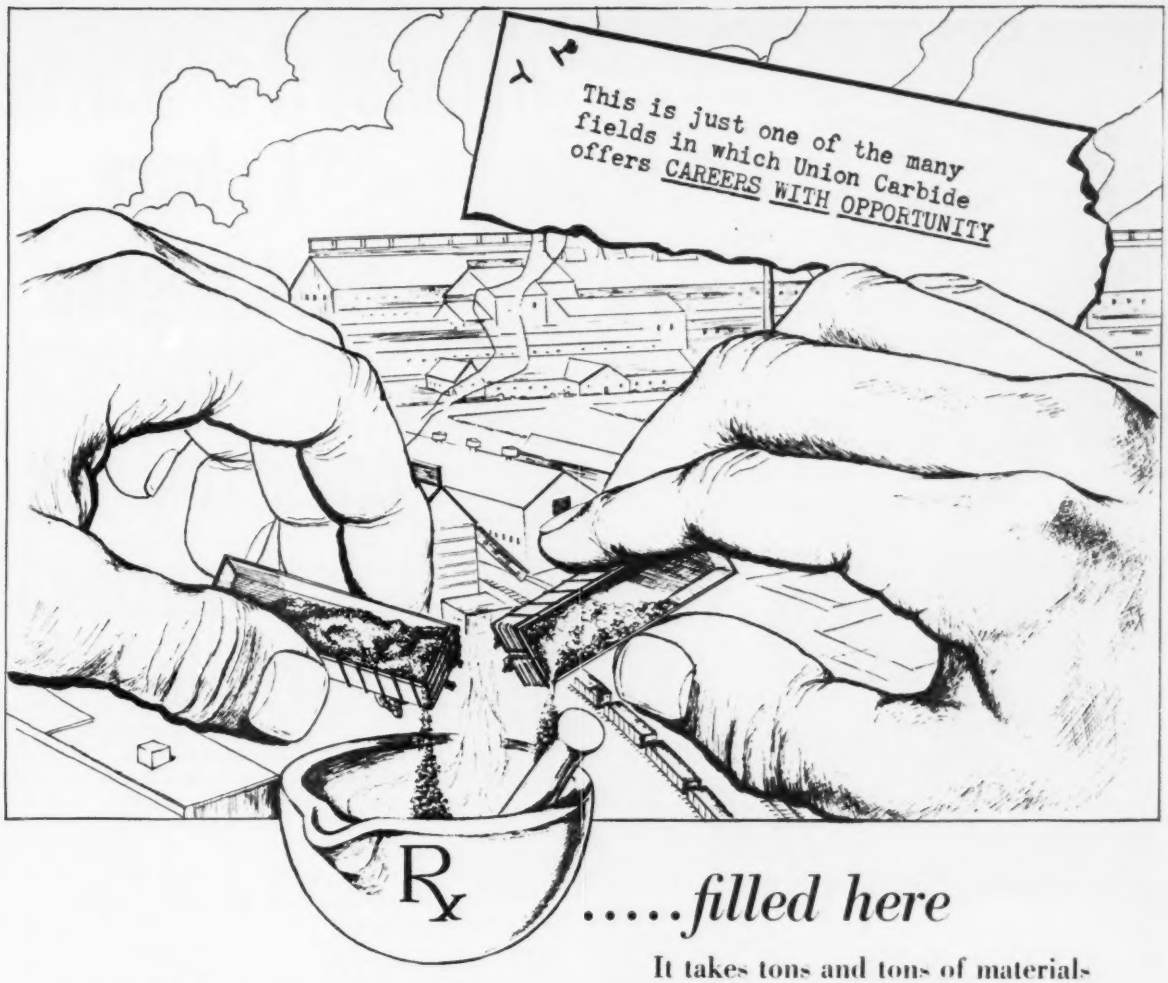
Both "Mein Jesu, mein Jesu, gute Nacht!" and "Wir setzen uns mit Traenen nieder" ("In tears of grief, dear Lord, we leave Thee"), the final choruses are done exceptionally on both recordings. Mengelberg reminds us once more of his varying tempi, not seriously, and both choruses are beautifully restrained.

After hearing either of these recordings straight through I feel I have been treated to an important and beautiful performance. However, neither completely satisfies me; Scherchen's rushing de-emphasis of Part I leaves much of the beauties contained in it untapped; Mengelberg's romantic variation of tempi can easily annoy me, as can his ommission of important and beautiful music. Despite a somewhat poorer orchestra and chorus (still very good!), Scherchen had it more within his power to give me a completely satisfactory performance; that he didn't merely indicates a difference of opinion of relative emphasis of different portions of the work. Mengelberg's romantic approach is inherently opposed to my idea of the work, although I honestly believe I can understand his purpose. Again, Part II of the Westminster is, for me, almost perfect; and it is this fact that has decided me in favor of the Westminster for my own collection. Whenever I feel the lack of a careful interpretation of arias and chorales in Part I, however, I shall always turn to the Columbia kindly loaned me for the next few years. Your decision will depend on what you want the work to be. Perhaps either of the two Vox recordings will appeal to you. Munch showed himself capable of a very fine performance last Spring, and RCA may yet record this work.

The Mengelberg performance was recorded in the Amsterdam Concertgebow six days before the outbreak of World War II. This fact will make it valuable to those collectors who want an example of the high performance level reached by the Amsterdam Concertgebow Orchestra before the war. This very fact makes it inferior in mechanical reproduction to the new Scherchen recording, but the reproduction of Dutch performance is better than may be expected. The sound was originally tape recorded (1939!) by the local radio station, and the LP set has been made directly from these tapes, presenting the beautiful sound of the excellent orchestra in the splendid hall with considerable fidelity. However, the tape was recorded through the limiter amplifier, the device used by stations to narrow the volume range of the broadcast material, and this device acted suddenly, causing loud thumps and abrupt changes in volume to appear several times during the recording. There is absolutely no excuse for Columbia's having permitted these to appear on the finished LP's, when any amateur tapeman could have reduced their effect at no cost to the music with a few hours of intelligent effort. Nevertheless, the sound will not be too annoying to anyone primarily interested in the music and the interpretation.

The sound on the Westminster disks is, in general, superb. I am not convinced, however, that the criticized lack of dramatic effect in the loud, sudden choral parts may not be a failure of the engineers to obtain proper balance. Certainly there is a fullness of sound from the chorus in the last sections of the work not obtained earlier. This overly restrained sound from the chorus is the only fault to be found in the Westminster recording—neglecting the effect of placing solo instruments a foot away from you, but it is an important fault.

Columbia presses both its own records and Westminster's. Over the last several years their pressing department has degenerated to the point where no one who reads this will be able to find albums of either recording without a side containing an unlistenable pressing fault, and anybody's time will be wasted in hunting among several albums to make up one album with no really bad faults. This is a sad commentary on the originator of the Microgroove record, but it is true.



.....*filled here*

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STEEL GETS ITS VITAMINS from the industry's "drugstores"—the plants where alloying metals are made. Here, prescriptions usually call for ingredients by the ton. Their huge "mixing bowls" are white-hot electric arc furnaces, in which temperatures reach over 3,500 degrees Fahrenheit.

These alloying metals are refined and concentrated forms of both rare and common metals. Among them are chromium, boron, silicon, tungsten, columbium, and vanadium. Individually, or together, they give steel durability, toughness, hardness, rust and corrosion resistance, and other special qualities. Chromium, for example, is the secret of making steel stainless.

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WORTHINGTON

THE SIGN OF VALUE AROUND THE WORLD

advice to freshmen

How to get good grades

by I. M. Brown and D. F. Shrader, '59

In the past two issues TEN has run articles advising instructors "How to Run Away From An Educational Problem" and "How to Write a Textbook". Now we believe it is our duty to aid the student.—Editor.

This article will be helpful only to those who recognize the full importance of grades, and are willing to go all out in the attempt to get the best. By adhering to the following instructions, we believe you can achieve this goal. Stupidity is no barrier.

Make sure you have a good supply of conservative suits, dull neck-ties, and a big fat brown leather bag. The bag should be used to carry the volumes of notes you will take in class. Never throw your notes away, so that in 8.72 lecture you can refer to 8.01.

Always look happy in class. Nod your head up and down at the end of each sentence you hear from the instructor. Be careful not to shake your head in the middle of a clause. This may confuse the instructor. Do not confuse the instructor at any cost. Ask many questions, but be sure to ask only questions the instructor can answer. Ask questions which will merely cause him to repeat what he has said previously.

Take notes in class. Later type them and bind them. Put them in your brief case. This will add to the volume of same, and make you look as if you are working hard. This will become increasingly true as the volume of your briefcase expands. It is not necessary to refer to these notes (although you probably will) since any sensible person knows they are useless.

Never miss a class, even though it is at nine in the morning. Never be late for class. Always laugh at the instructor's jokes. When the instructor laughs, you can assume he has told a joke; otherwise it means a snap quiz.

Sit in front of the class, so the teacher will eventually get to recognize your face. This often helps, but remember that smile! If you must yawn, bury your face in your notebook, thereby giving a studious impression.

Try to make the class as pleasant as possible to your instructor, and as disgusting as possible to your classmates. In this way you may eventually become the only student attending, thereby assuring yourself of an A.

Now we come to a matter which involves some sensitivity and judgment. This will be extremely difficult for you to master. Speak to the instructor after class. Ask him a question, any simple question, then shake your head and smile as he answers. Visit him at his office a few times in the term. But do not waste too much of his time or you will not achieve the desired results. This is the only matter in which any degree of judgement or intelligence is involved.

After getting a quiz back, no matter what your grade is, go up to the instructor, explain your paper in detail, and hope that to get rid of you he will raise your grade slightly. These few points may not seem important at first, but they add up!

Consider that there are only a limited number of hours in the week. Make good use of them. There are many hours between classes which can be put to use in memorizing the book. Don't waste any time with such things as movies, dances, sports, or concerts. They are all useless in getting good grades. The time could better be spent greasing your slide rule. In addition, eight hours of sleep are really unnecessary. You can go to bed as late as two in the evening, and get up as early as seven in the morning to study. Think of the extra time you will gain. You can postpone sleep

until after you graduate (or maybe after you retire, or maybe after you're dead). The Institute Dining Service is not fully appreciated by many students. They have such mundane interests as good food. However, they do not realize that as much as a half hour can be saved per meal by eating at the Institute Dining Halls. Just think, this adds up to an extra ten hours of study per week! Stay away from all extra-curricular activities, with the exception of student government, and then only if you are certain that you don't have the mentality to get an A with any amount of studying. In student government you can get to meet the Dean, and shake hands with the President. It's amazing how such acquaintances can help.

Some closing advice: Remember that your grades are all-important, your education irrelevant. Don't let thought get in your way. You might come up with an original idea, and this can cause trouble.

Whenever fastening problems arise...

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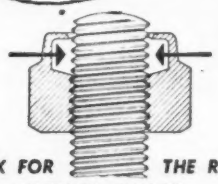

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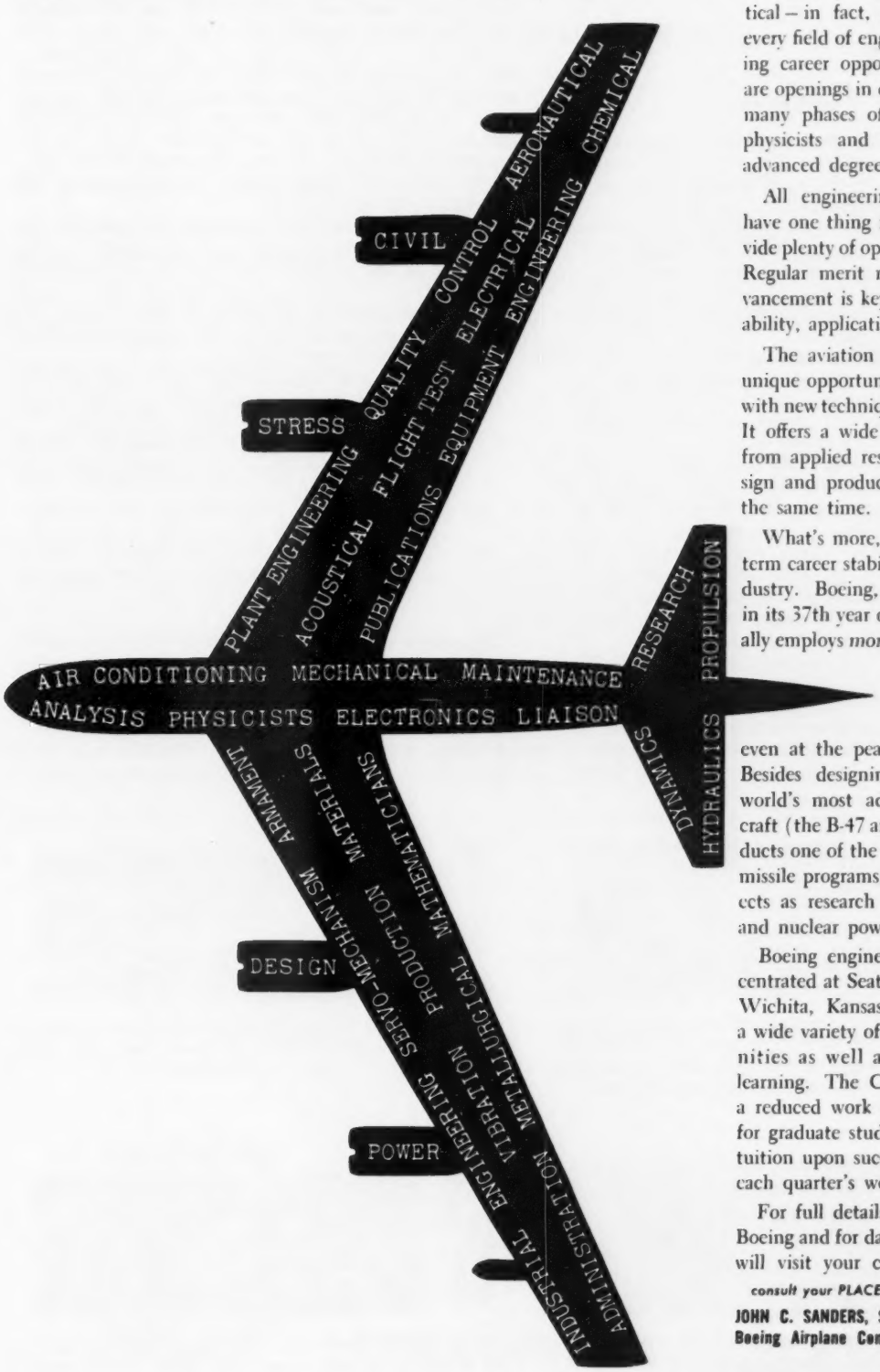

Mechanical, electrical, civil, aeronautical – in fact, graduates in virtually every field of engineering–find rewarding career opportunities here. There are openings in design, research, in the many phases of production, and for physicists and mathematicians with advanced degrees.

All engineering careers at Boeing have one thing in common: they provide plenty of opportunity to get ahead. Regular merit reviews are held. Advancement is keyed to your individual ability, application and initiative.

The aviation industry offers you a unique opportunity to gain experience with new techniques and new materials. It offers a wide range of application, from applied research, to product design and production, all going on at the same time.

What's more, you can expect long-term career stability in the aviation industry. Boeing, for instance, is now in its 37th year of operation, and actually employs *more* engineers today than even at the peak of World War II. Besides designing and building the world's most advanced multi-jet aircraft (the B-47 and B-52), Boeing conducts one of the nation's major guided missile programs, and such other projects as research on supersonic flight, and nuclear power for aircraft.

Boeing engineering activity is concentrated at Seattle, Washington, and Wichita, Kansas – communities with a wide variety of recreational opportunities as well as schools of higher learning. The Company will arrange a reduced work week to permit time for graduate study and will reimburse tuition upon successful completion of each quarter's work.

For full details on opportunities at Boeing and for dates when interviewers will visit your campus,

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JOHN C. SANDERS, Staff Engineer – Personnel
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BOEING

briefing the news

ultrasonics

The Acoustigraph

The development of an ultrasonic technique for the non-destructive testing of certain non-metallic solids, sponsored by the Navy Bureau of Ordnance, has recently been completed.

Prototype test equipment, incorporating ultrasonic absorption techniques and automatic scanning, has now been built which will produce high contrast records of simulated flaws, or mechanical defects, which were imperceptible in x-ray photographs of the same sample.

In this new system a pair of barium titanate transducers are arranged to transmit and receive acoustic energy (Continuous Wave Transmission at 383 Kilocycles/second) along radii of the cylindrical test sample which is revolved about its longitudinal axis at 100 RPM. The transducers simultaneously traverse the length of the cylinder at a rate of approximately 0.1 inch per revolution of the cylinder, producing a helical scan the full length of the sample. This entire assembly is submersed in water for good acoustic coupling. The scanning mechanism is coupled through gears to a cylindrical recording drum having the same angular velocity as the test sample.

The output from the receiver transducer is fed through appropriate electronic circuitry to a tungsten stylus held in contact with electro-sensitive paper mounted on the recording drum. As in facsimile recording, the stylus traverses the length of the rotating drum, leaving a trace whose intensity (dot size) corresponds to the level at the receiver.

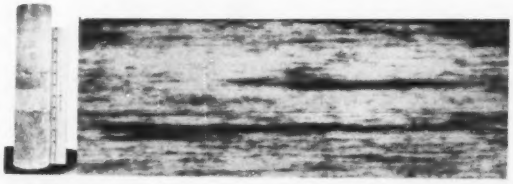
The resulting record, or ACOUSTIGRAPH, may be interpreted in the same manner as a positive radiograph which might be obtained by passing an x-ray source along the center perforation of a stationary cylinder wrapped with photographic film. Dark areas in both types of records represent regions of decreased transmission through the material being inspected. However, the Acoustigraph can be obtained at any convenient scale. In the present equipment, a sample fourteen inches long is represented by three inches on the record, a full revolution by nine inches.

It can be seen that the new system combines the major advantages of x-ray and ultrasonic testing methods as identified by the following distinctive features:

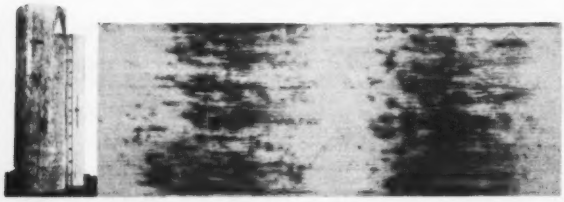
(a) Immediate availability of test results (no processing) in an easily interpreted form (graphic presentation).
(b) Inherently high sensitivity to internal mechanical flaws (voids, cracks, porous regions, poor bonds, density variations).
(c) Easily controlled contrast and differential sensitivity in the final record (non-linear electronic amplification).
(d) Freedom from high voltage and radiation hazards.
(e) Low initial and operating costs (Recording paper costs approximately three cents per sheet).

Although the present equipment was designed to fulfill a particular need, it is apparent that the combination of basic principles employed are applicable to a wide variety of inspection problems. As an illustration, cylindrical samples of wood, bakelite, rubber, graphite and concrete were fabricated and tested with the equipment. Figures 1

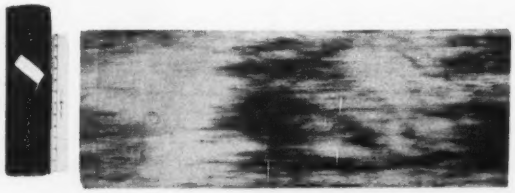
Acoustigraph of bakelite (Formica) cylinder shows clearly the triangle of masking tape stuck to cylinder's surface as well as other surface imperfections. Only slight variations could be attributed to losses through the material itself.



Acoustigraph of concrete cylinder shows narrow horizontal bands due to layers of sand and wood chips introduced during casting.



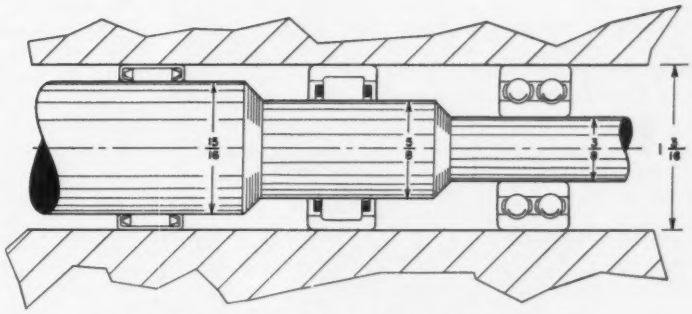
Acoustigraph of hard wood (Oak) distinctly shows broad vertical bands distinguishing between transmission "with" and "across" the annular rings.



Acoustigraph of hard rubber cylinder formed by vulcanizing strips of 1/2 inch sheet stock shows broad vertical bands representing transmission differences "with" and "across" the bonds.

The Torrington Needle Bearing
is designed for high radial loads

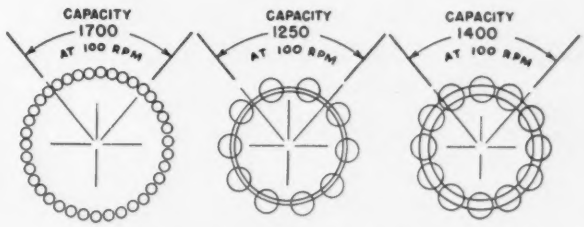
The many lineal inches of contact provided by the larger number of small diameter rollers give the Torrington Needle Bearing an unusually high load rating. In fact, a Needle Bearing has greater radial capacity in relation to its outside diameter than any other type of anti-friction bearing.



1. *Illustrates the fact that for a given housing bore size, a larger and, therefore, stiffer shaft can be used with Needle Bearings than with a roller or ball bearing.*

Precision Manufacture and Unique Design

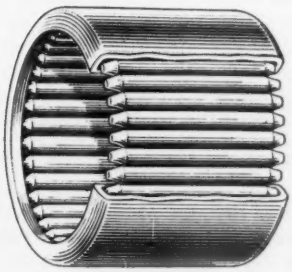
The exceptional load capacity of the Needle Bearing is the result of proper selection of steels, precision workmanship to close tolerances, and the application of modern anti-friction principles.



2. *Shows the greater number of lines of contact in the load zone of a Needle Bearing compared with a ball or roller bearing.*

The one-piece shell, which serves as the outer raceway and retains the rollers, is accurately drawn from carefully selected strip steel. After forming, it is carburized and hardened. There is no further grinding or other operation that might destroy the wear-resistant raceway surfaces. The full complement of thru-hardened, precision-ground rollers is retained by the turned-in lips of the one-piece shell.

The small cross section of the Needle Bearing allows a large shaft which permits a rigid design with minimum shaft deflection, a factor of utmost importance to good bearing design.



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Acoustigraph of extruded graphite cylinder shows intensive variations. The sample was sectioned at the point of maximum absorption, revealing a very fine flow line structure somewhat coarser than in other regions.

through 5 show photographs of the samples with their corresponding ACOUSTIGRAPHS. Obviously, other simple geometric shapes such as rectangular blocks, flat plates and thin sheets could be handled by a scanning mechanism employing motions of translation rather than rotation.

Where details of the flaw (shape, size and location) are of secondary interest relative to its presence, the system could be extended to accomodate much more complicated shapes by comparing patterns in the test record with those in a standard record representing a flawless piece.

In all non-destructive testing it becomes necessary to establish acceptance-rejection criteria, which are generally based on correlation between some relatively indirect indication of flaws in a group of specimens with the actual operational performance (usually destructive of the same group).

For many problems, the Acoustigraph will provide a cheaper and much more sensitive indication than x-rays. Furthermore, it will provide a permanent record in a form which is much easier to interpret and correlate than conventional Ultrasonic displays.

Metal Ultrasonic Delay Lines

The National Bureau of Standards recently completed an investigation of metal ultrasonic delay lines for application in electronic computers and ordnance devices. The study disclosed that use of isoelastic alloys containing combinations of iron, nickel, chromium, and other minor elements may solve one of the primary problems in this field—finding materials that yield a thermally stable delay line with respect to time delay.

A delay line is a device for slowing down or storing a signal in an electric circuit. At radio frequencies this can be done by transforming the electric signal into a much slower sound signal and propagating it through an appropriate medium. After a given length of time the sound signal is converted to an electric signal again. Delay lines are employed in radar, computers, and many new ordnance devices.

The use of isoelastic alloys for delay lines is apparently new, although such materials have been known and used in other applications for over fifty years. Isoelastic alloys are ones which have a constant modulus of elasticity with respect to temperature changes. Their primary use to date has been in watch springs and similar applications. Since one of the requirements for ordnance delay lines is ability to give constant signal delay regardless of temperature changes, only the isoelastic alloys and relatively few other materials can be considered for such a use.

Up to the present time quartz, mercury, water, and certain magnesium alloys have exhibited some of the qualities needed for use in ultrasonic delay lines. Quartz and mercury have been used fairly extensively in certain applications, but both have drawbacks. Quartz is expensive and hard to shape or machine while mercury is thermally unstable and is susceptible to mechanical shock, leakage, aging, and contamination. Mercury has been used, however, in the long delay lines of the National Bureau of Standards Eastern Automatic Computer. In some devices it is desirable to use a material that will transmit 10-megacycle pulses, without appreciable attenuation or distortion of the signal, and give a 50 micro-second time delay. At the same time the material must be thermally stable and be easily shaped into specific dimensions. No delay lines developed so far have all these qualities.

Before the delay lines could be investigated, certain problems relating to the transducers used to transform the signal had to be solved. Quartz-crystal transducers were found to be the most efficient elements. The crystals were cut so that they transmitted only shear waves. Careful acoustical matching between delay line and crystal was required. The Bureau adopted a buffer technique for preliminary tests in which crystals were cemented to short lengths of magnesium alloy rods. A special clamp was devised to hold the unmounted ends of these buffers against the delay lines under test. In the second method for attaching crystals to delay lines, the one which was used in the final investigations, crystals were cemented directly to the delay lines as they would have to be in potential service use. Best signal characteristics were obtained using epoxy type cement and overcuring it.

Although the principal objective was to obtain a line of a length which would produce a delay of 50 microseconds, specimens of various lengths were studied. This was done to determine the attenuation per unit length and the transducer or buffer loss associated with the various materials. Delay line length varied from ¼ inch to over six inches. The NBS study revealed that there was little effect on the transmission of ultrasound attributable to specimen cross section so long as it was not less than transducer cross section.

NBS investigated fourteen materials in the course of the work. A number of characteristics such as attenuation, distortion, and temperature response were studied for each material. The total attenuation of a high-frequency signal is the result of several factors. Besides losses in the delay line itself, there are losses due to the crystal transducer and due to the bond between the crystal and delay line. The attenuation losses of the line have been attributed to elastic hysteresis,

A CAMPUS-TO-CAREER CASE HISTORY

A Second Education

What makes a job hold its interest? After working for three years, Wylie Borum, E. E., '50, tells us what has kept his interest alive.

(*Reading time:* 38 seconds)

He graduated from the University of Pennsylvania in 1950, but Wylie Borum's education still hasn't ended. His job, he explains, has become his second education. And this continuing process of learning has kept his job interesting.

Wylie's first year at Bell Telephone Company of Pennsylvania was spent as a student engineer, which he feels was not only educational but extremely worth while. For it was while he took this course that he glimpsed the complexity of the business in considerable detail. He worked in all departments – ran switchboards, climbed poles and even did a stint in the Accounting Department.

Wylie discovered that there were many spots in the telephone organization for engineers besides the General Engineering Department. Even in Accounting – which today is highly mechanized with things like Centralized Automatic Message Accounting Machines.

Training finished, Wylie was assigned to the Manual Equipment Section of the General Engineering Department. His education continued. He found out, he reports, that the dollar is an important part of engineering. In writing equipment specifications, he had to be sure of reasonable cost as well as efficient operation. There's a big difference, he discovered, in doing a theoretical job in school and doing a job in which costs are an important consideration.

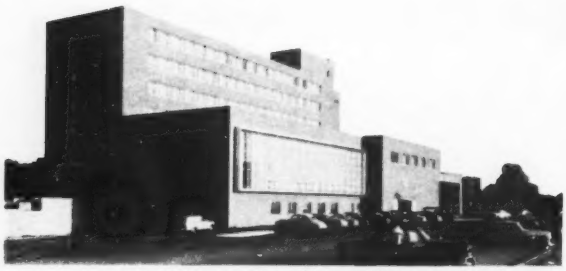
Now Wylie has been promoted to the Plant Extension Engineering Group and still is learning. His present job is co-ordinating plans for replacing the last manual central office in Philadelphia with a dial system. The cost will be approximately $1,500,000.

It's a big responsibility. But the Telephone Company puts capable young men on their own quickly.

• • •

Wylie Borum's job is with an operating company of the Bell System. But there are also job opportunities for engineers in Bell Telephone Laboratories, Western Electric, and Sandia Corporation.

BELL TELEPHONE SYSTEM



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sound scattering, and a sound diffusion process. Distortion also has several sources. It can be caused by the crystal transducer or by the matching between crystal and delay line. Internally, the principal sources of distortion are scattered signals which have been reflected or refracted back into the main beam. To investigate these effects, the laboratory made studies of the relationships between the transmission of ultrasound and such factors as chemical composition, cold deformation, annealing treatment, specimen length, and sound path cross section.

The third, and most important quality, sought in the NBS investigation was temperature stability of time delay over the range from -50° to +200°C. The delay time of a delay line is affected by the length and the shear modulus of the material. For most metals, the temperature coefficient of the modulus is negative and of much greater magnitude than the positive expansion coefficient. Actually, the expansion coefficient is relatively small especially for certain alloys of iron and nickel. Consequently a thermally stable delay line material must have a very small negative temperature coefficient of shear modulus.

Materials chosen for study included two magnesium alloys, a high purity and a commercial nickel, Invar, a 32 percent nickel-iron, and 18:8 Cr-Ni steel, a 1 percent carbon tool steel, an aluminum single crystal, and five isoelastic alloys.

The electronic apparatus consisted of an RF signal generator and amplifier; pulse, marker, and delay generators; an output cathode follower; and an oscilloscope. For attenuation studies, a pulse modulated signal was fed into both the ultrasonic delay line and directly into the oscilloscope. The outputs were applied to the vertical input of the oscilloscope. As the oscilloscope deflection sensitivity and circuit constants were known, the attenuation of the delay line could be determined. For delay time studies, the marker generator provided marker pulses for the vertical input of the oscilloscope and synchronized the pulse generator output which was being applied to the delay line. The delay generator was synchronized by the pulse generator and provided in its output a delay pulse which was used to trigger the oscilloscope sweep. The sweep delay was variable over a wide range. By this method, the expanded sweep could be observed over a wide range, facilitating accurate determination of the delay time of the delay line.

For tests at elevated temperatures, a nichrome-wound alundum tube furnace was used having a uniform temperature zone over the specimen length. Thermocouples were attached to the center and both ends of the delay line. In order to obtain sub-zero temperatures, a very simple but effective low-temperature test chamber was constructed. It consisted of an open-top wooden box with holes drilled in its opposite ends. A thick-walled copper tube ran through the holes. The delay lines were inserted in the tube. By gradually filling the box with dry ice, the specimen was cooled slowly. The copper tube maintained effectively uniform temperatures over the specimen length.

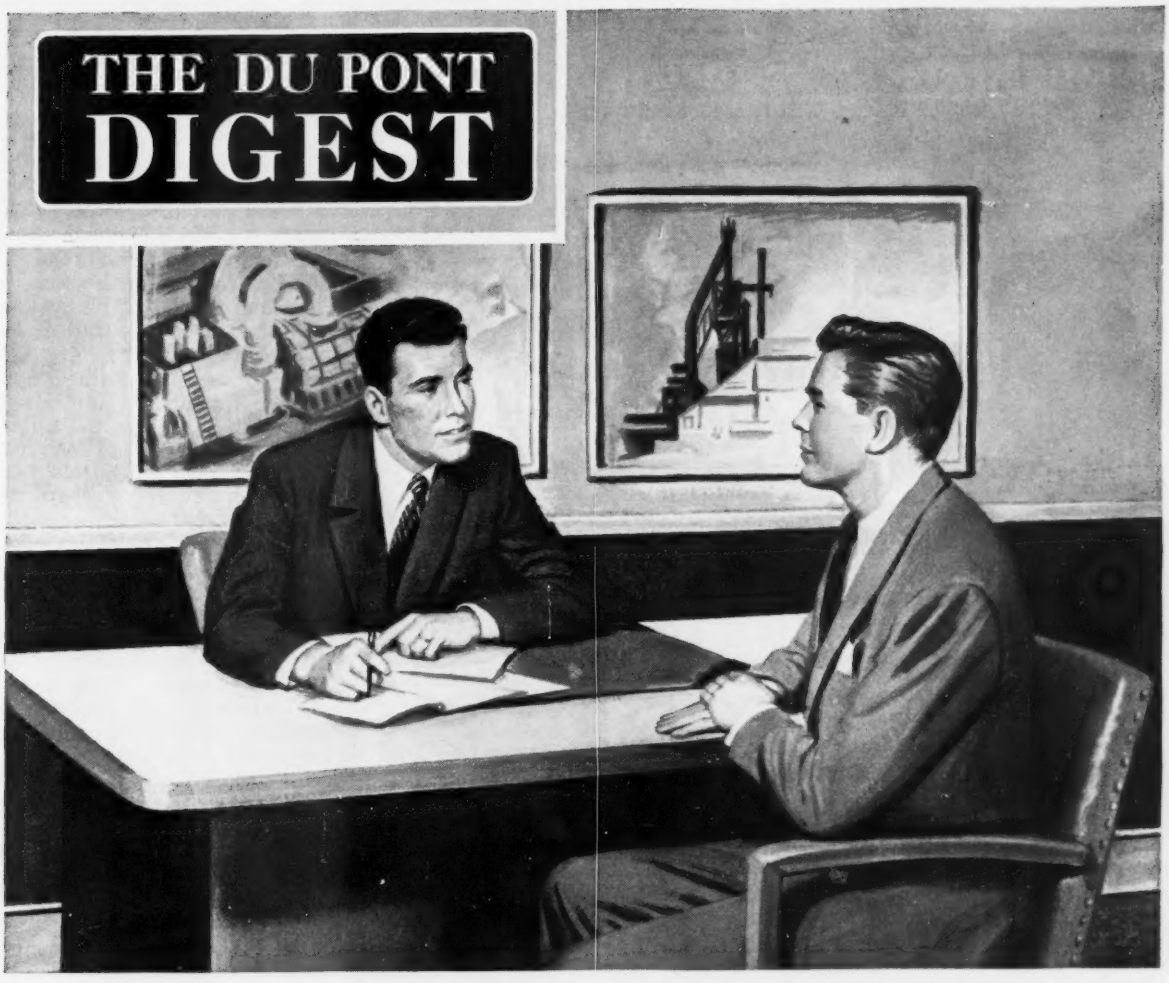
Of the fourteen metals and alloys investigated, only two of the isoelastic alloys possessed satisfactory temperature stability over the range from -50° to +200°C. These materials were alloys of iron, both containing approximately 36 percent nickel and seven to eight percent chromium plus other minor constituents. While mercury and the magnesium alloy have temperature coefficients of delay time of about 300ppm/°C and 400ppm/°C, respectively, one of the isoelastic materials tested had a temperature coefficient of only 8ppm/°C. The second isoelastic alloy was nearly as good; it exhibited a constant delay time over the range from -50° to +170°C, with a slight increase in delay time at temperatures above 170° Centigrade.

at M.I.T.

Cloud Biographies

Professor Delbar P. Keily, Dr. John C. Johnson, and Ralph G. Eldridge reported on a one-month successful trial operation of their new equipment for measuring cloud drop sizes on Mount Washington last fall, at the national meeting of the American Association for the Advancement of Science in Boston.

The new equipment, developed in the M.I.T. Department of Meteorology under sponsorship of the Geophysical Research Directorate of the Air Force Cambridge Research Center, determines the



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2. Recognition—the assurance that good work will be noticed, appreciated, and properly rewarded.
3. Opportunities for advancement—a growing company can provide them.
4. Security—the knowledge that a company is both stable and progressive.
5. Pride—a feeling that your company is respected by the public and produces goods which contribute to a better way of life.
6. Good companionship—a factor which contributes greatly to happiness on the job.
7. Good pay—not in salary alone, but also in terms of vacation plans, pensions, and other benefits.
8. Safe working conditions.

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One of the best ways is to discuss the matter with an acquaintance already working for the company you are considering. You will also find it helpful to consult your college placement officer, your professors and company representatives visiting your campus.

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SOON AVAILABLE for student ASME chapters and other college groups, a 16-mm. sound color movie—"Mechanical Engineering at Du Pont." For further information, send post card to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware.

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size and number of drops "smaller than have been measured before," Professor Keily says. It estimates the size and number of droplets as small as 4/10,000ths of an inch in diameter; a cubic inch of ordinary cloud may contain 500,000 such tiny droplets, each less than 1/100 the size of the smallest drops in a drizzly rain.

Clouds are formed when invisible water vapor collects into visible droplets of water, at first very small. These tiny droplets contain the key to the mystery of how clouds grow—they are the critical stage in the process by which water in the atmosphere goes from invisible vapor to drops large enough to be rain. Such tiny drops are believed to exist for a short time; they must either grow larger or evaporate. The new instrument is important because it will allow meteorologists to study the behavior of very small droplets, closer than ever to these critical sizes which are the true ancestors of raindrops.

Professor Keily and his associates call the new equipment a "variable frequency infrared cloud transmissometer." It consists of an electric eye looking through a part of the cloud in question toward a light source about four feet away. The eye measures the changes in brightness of the light source caused by intervening droplets of the cloud. The light source is invisible "infrared" radiation, chosen because it undergoes large changes on passing through a cloud of very small droplets.

To find the actual sizes of drops, observations of brightness made with the cloud spectrograph must be compared to intensities derived from theoretical data. The theoretical computations, the key to the usefulness of the new device, were originally made on M.I.T.'s large electronic computer, Whirlwind I, under Dr. Johnson's direction.

The cloud spectrograph proved its effectiveness this fall in a month's operation by Mr. Eldridge on Mount Washington, the highest point in New England and one of the stormiest mountains known. That location was chosen, the meteorologists explain, to assure plenty of clouds in which to work.

Future development of the cloud spectrograph, Professor Keily and his associates believe, will be toward an airborne instrument of greater accuracy and dependability than the present experimental model. An airborne cloud spectrograph, carried on successive passes through a cloud, could get the full life history of that cloud from its first appearance to its maturity as a rainstorm . . . without any of the side effects which may occur as a cloud passes over a mountaintop. Such a history of the hour-by-hour and minute-by-minute changes in cloud drop size and number is necessary to a full understanding of when and why it rains.

Irradiation of Foods

Sterilization of food products may soon be an important commercial peacetime use of atomic energy.

For the first time, waste products from atomic bomb manufacture are now to be used for experimental irradiation of foods in the laboratories of the Department of Food Technology at the Massachusetts Institute of Technology.

The Argonne National Laboratory, operated by the University of Chicago in Lemont, Illinois, has shipped to M.I.T. the first of a new type of experimental radiation source which uses nuclear reactor waste products.

At M.I.T. this source is to be used in connection with equipment which will for the first time make possible irradiating food in commercial-sized containers.

This, says Professor Bernard E. Proctor, head of the M.I.T. Department of Food Technology, brings commercial sterilization of food by radioactivity an important step nearer: the radioactive fission products to be used at M.I.T. are a waste product, presumably inexpensive, and they will be used under conditions which for the first time approximate those needed in commercial food production.

electronic translation: a few sobering comments.

by Berthold Lippee, '56

In last month's issue of TEN there appeared an article entitled "Electronic Translation", relating with trumpets, fanfares and a slight science fiction flavor the combined exploits of Georgetown University and IBM in the field of machine translation. For the sake of veracity and in order to counteract somewhat the "Hollywood Press Agent" approach to scientific news, I want to analyze this piece of publicity and, I am afraid, tarnish somewhat the halo of the parties involved in the process.

The distinct impression the article created was that raw, unprepared Russian scientific writings could be fed into the IBM 701 computer, and "in the twinkle of an eye" (Mr. Watson's eye undoubtedly), the machine produces the English translation in beautiful King's English. This is a lovely, but incomplete, story. The part that was left out, however, is an integral and significant part of the whole picture, and it is interesting to fill in the missing aspects.

A careful examination of the sample Russian text fed to the machine shows clearly that it consisted either of carefully selected phrases having a syntax identical to their English counterpart, or of sentences transformed from their Russian construction into a word sequence that the equivalent English phrase would have. The latter procedure is known in machine translation lingo as "pre-editing", and signifies in essence that a person skilled in the language to be translated arranges the text in a rough order prior to feeding it to the machine. Now this is a valid, if somewhat inefficient, method of machine translation. Compare the preceding however with the contention in the article that: "a girl who didn't understand a word of the language of the Soviets punched out the Russian messages on IBM cards. The brain dashed off the English translation . . . (etc.)." This clearly is a misleading statement in its implication that the text had not undergone any modification or selection before translation.

Another important point the article completely failed to mention was the factor of "programming." Programming is a term used by computer people and consists of charting step by step the operation and actions of the computer. The grapevine has it that the programming of the short text used for the press-conference demonstration necessitated a few months of programming, which creates serious doubts as to the "revolutionary" progress to be achieved by the methods used in this demonstration.

The aim of machine translation is to be able to translate faster than the human expert can. One must realize that the speed of translation does not depend on the speed of the machine, but rather on the speed with which information can be supplied to the machine. If, as was the case in this demonstration, the material has to be pre-edited, the speed of translation is limited by the speed of the human expert who does this job. At that point the whole value of machine translation is evidently placed in question.

There is a further statement in the article which requires some rectification. It states that "no practical results have even been achieved by the handful of men studying machine translation at various institutions". To this imputation of failure, quite a handful of this handful reply that what IBM demonstrated recently is an elementary experiment they could have produced at least three years ago using any of the computers extant at that period. Nobody felt compelled to do so however, for the simple reason that this translation method offered no practical prospects for the future and that there was no point in confusing the public by an impromptu bit of "wizardry".

More and more workers in the computer field deplore the sensational publicity and inaccurate anthropomorphic interpretations fed to the public about electronic computers. Legions of people have acquired as a result the notion that computers are in the forefront of the fight of the machine against humanity, and will one day band together and subjugate the human species to the rule of the machine. It is time that such nonsense be fought, and the electronic computer placed in its correct perspective of tool of man, and its limitations as well as capabilities clearly pointed out to the public.

In conclusion, and to leave the negative side of things, it can be pointed out that research in machine translation is continuing lustily in many places, among others right here in M.I.T. Promising and realistic progress is being made, mostly along the logical and practical lines of "post-editing". Under this concept, the text to be translated is given to the machine without previous modification or editing, is roughly translated by the machine, and is then transformed to correct English by a human post-editor. The advantages of this method are evident. The post-editor does not have to know the language the text is translated from; also post-editing is a very much faster process than pre-editing or human translation, and requires no specialized and scarce skill.

The day of machine translation in the form of concrete reality is yet to come. But it will, as the result of serious and painstaking research, rather than meaningless theatricals.

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This giant computer, located in IBM's main New York office, is one of 12 already in use. It has been working at top speed from 16 to 24 hours a day ever since it was installed.

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It has helped a petroleum company blend its gasolines and figured out a multi-million dollar annual budget for a complex supply operation.

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In the solution of the wide variety of problems suited to its great capacity, the "701" does the job with tremendous savings in time and money for its users.

How Science Uses the "701"

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- Analysis of the structure of the atom
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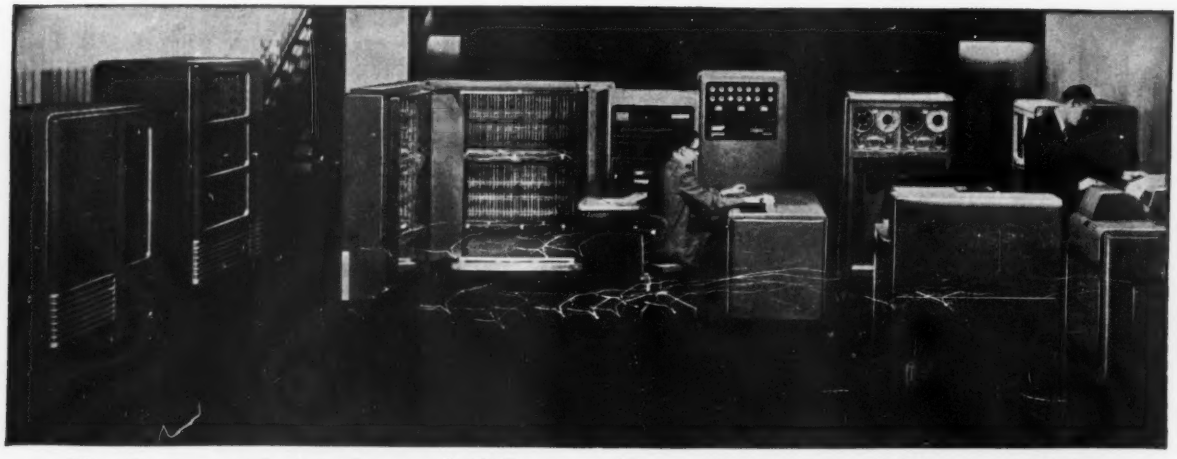
- Magneto-ionic refractions
- Trajectory calculations
- Reactor design
- Seismic wave calculations



These eleven connected units are known as the IBM Type 701 Electronic Data Processing Machines. The average age of the engineers, physicists, mathematicians and technicians who developed and designed these machines, which embody the latest advances in electronic computing circuitry and high speed mechanisms, was 28.

If you are interested in a technical or non-technical explanation of how the "701" operates, the IBM staff at 590 Madison Avenue, New York City, would welcome your visit. Visiting hours are from 10:00 A.M. to 4:00 P.M. daily except Saturdays, including Spring and Summer vacation periods.

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Cast iron pipe is the standard material for water and gas mains and is widely used in sewage works construction. Send for booklet, "Facts About Cast Iron Pipe." Address Dept. C., Cast Iron Pipe Research Association, T. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3, Illinois.

Section of 130-year-old cast iron water main still in service in Philadelphia, Pa.

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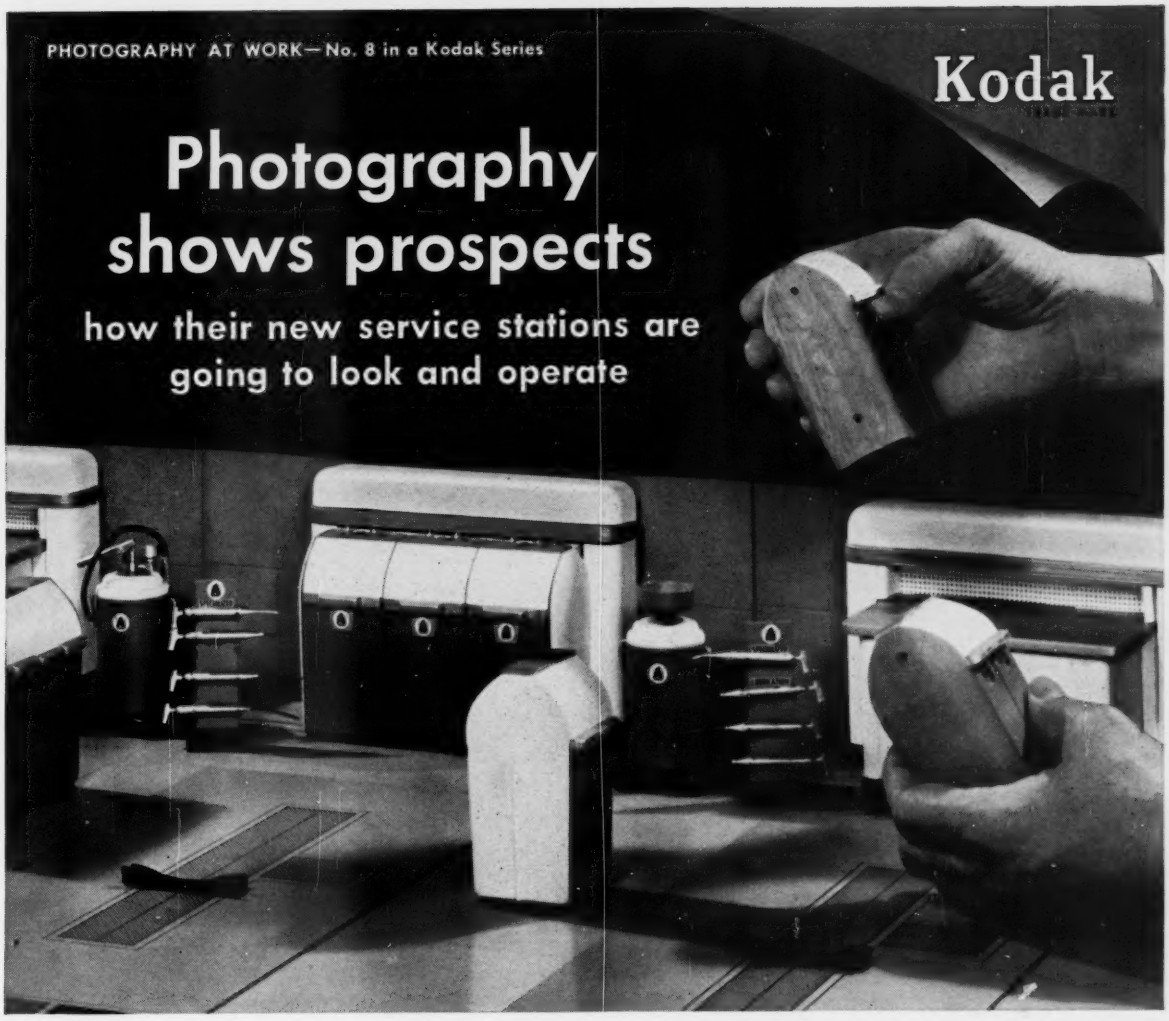
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Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. Whether you are a recent graduate or a qualified returning service man, if you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N.Y.

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